

DENISON UNIVERSITY BULLETIN

Volume XXVIII, No. 8

JOURNAL OF THE SCIENTIFIC LABORATORIES

Volume XXIII

Articles 3-5

Pages 127 to 230

EDITED BY

W. C. EBAUGH

Permanent Secretary Denison Scientific Association

3. Some Brachiopods from the St. Clair Limestone, Arkansas. By Norman L. Thomas..... 127
4. The Phytosauria of the Wyoming Triassic. By M. G. Mehl..... 141
5. A Restudy of some of the Ordovician and Silurian Cephalopods described by Hall. By Aug. F. Foerste..... 173

GRANVILLE, OHIO

JULY, 1928

The University Bulletin is issued bi-monthly and is entered at the Post Office in Granville, Ohio, as mail matter of the Second Class

JOURNAL OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY

The entire file of volumes 1 to 13 was destroyed by fire; no publications issued prior to 1907 are now available. Volumes 14 to date may be obtained from the editor at \$2.00 per volume, with the exception of volume 15, the price of which is \$1.00. Separate parts, as listed below, may be purchased at the prices indicated.

VOLUME 14

Articles 1-5, pp. 1-60; Nov., 1908.....	\$0.50
Pre-Wisconsin drift in the Finger Lake Region of New York; F. Carney. 10 pp., 4 figs.	
An esker group south of Dayton, Ohio; Earl R. Schaffel. 15 pp., 6 figs.	
Wave-cut terraces in Keuka Valley, older than the recession stage of Wisconsin ice; F. Carney. 12 pp., 3 figs.	
A form of outwash drift; F. Carney. 8 pp., 1 fig.	
State geological surveys and practical geography; F. Carney. 6 pp.	
Articles 6-10, pp. 61-125; April, 1909.....	\$1.00
Fossils from the Silurian formations of Tennessee, Indiana, and Kentucky; Aug. F. Foerste. 56 pp., 4 plates.	
Studies on Babbitt and other alloys; 10 pp. J. A. Baker.	
A stratigraphical study of Mary Ann Township, Licking County, O. 28 pp., 15 figs. F. Carney.	
Significance of drainage changes near Granville, Ohio; Earl R. Schaffel. 17 pp., 2 figs.	
Age of the Licking Narrows; K. F. Mather. 13 pp., 5 figs.	
Articles 11-16, pp. 126-267; June, 1909.....	\$0.75
A spectrometer for electromagnetic radiation; A. D. Cole. 10 pp., 6 figs.	
The development of the ideas of glacial erosion in America; F. Carney. 10 pp.	
Preliminary notes on Cincinnati fossils; Aug. F. Foerste. 20 pp., 1 plate.	
Notes on Spondylomorom Quaternarium Ehrenb; M. E. Stickney. 5 pp., 1 plate.	
The reaction to tactile stimuli and the development of the swimming movement in embryos of <i>Diemycotylus torsus</i> , Eschscholtz; G. E. Coghill. 21 pp., 6 figs.	
The raised beaches of the Berea, Cleveland, and Euclid sheets, Ohio. F. Carney. 25 pp., 5 figs.	
Articles 17-18, pp. 268-442; November, 1909.....	\$1.00
Preliminary notes on Cincinnati and Lexington fossils; Aug. F. Foerste. 45 pp., 5 plates.	
The Pleistocene geology of the Moravia Quadrangle, New York; Frank Carney. 105 pp., 27 figs.	

VOLUME 15

Article 1, pp. 1-100; March, 1910.....	\$1.00
Bulletin in commemoration of Clarence Luther Herrick.	

VOLUME 16

Articles 1-3, pp. 1-120; June, 1910.....	\$1.10
The metamorphism of glacial deposits; F. Carney. 14 pp., 7 figs.	
Preliminary notes on Cincinnati and Lexington fossils of Ohio, Indiana, Kentucky, and Tennessee; Aug. F. Foerste. 81 pp., 5 figs., 7 plates.	
The abandoned shorelines of the Oberlin Quadrangle, Ohio; Frank Carney. 14 pp., 5 figs.	
Articles 4-7, pp. 119-232; Dec., 1910.....	\$0.75
Standardization of well water in the vicinity of Granville, Ohio; Lily Bell Sefton. 5 pp.	
Chapters on the geography of Ohio; F. Carney.	
Transportation; 11 pp.	
Economic mineral products; 47 pp.	
Glaciation in Ohio; 48 pp.	
Articles 8-12, pp. 233-346; April, 1911.....	\$0.75
The abandoned shorelines of the Vermilion Quadrangle, Ohio; F. Carney. 12 pp., 2 figs.	
Thermo-electric couples; A. W. Davidson. 21 pp., 10 figs.	
The Mercer limestone and its associated rocks in the Newark-Zanesville region; Clara G. Mark. 47 pp., 2 plates	
5 figs.	
A study of the supposed hybrid of the Black and Shinglecocks; Earl H. Foote. 18 pp., 4 plates.	
A case of pre-glacial stream diversion near St. Louisville, Ohio; Howard Clark. 5 pp., 4 figs.	
Articles 13-17, pp. 347-423; July, 1911.....	\$0.85
The Sweeney Observatory, Denison University; Herbert G. Wilson. 5 pp., 4 figs.	
The contribution of Astronomy to general culture; Edwin B. Frost. 12 pp.	
The geological development of Ohio; F. Carney. 16 pp.	
The relief features of Ohio; F. Carney. 13 pp., 1 fig.	
Geographic conditions in the early history of the Ohio country; F. Carney. 20 pp.	

SOME BRACHIOPODS FROM THE ST. CLAIR LIMESTONE, ARKANSAS¹

NORMAN L. THOMAS

Received April 13, 1928; published August 9, 1928

This paper describes a few *Atremata* and *Protremata* from the St. Clair Limestone of Silurian age, taken from the outcrops near the city of Batesville, Arkansas. Bulletin 52 of the United States National Museum has been used as a bibliography and the references included in this paper are those which are not to be found in that bulletin. Some of the *Telotremata* were described in the Denison University Bulletin, Journal of the Scientific Laboratories, Vol. XXI, September, 1926. The author wishes to acknowledge valuable aid in preparing the plate by C. O. Dunbar of Peabody Museum, as well as those mentioned in the first article. The specimens are deposited with the Peabody Museum.

I. ATREMATA

Orbiculoidea or Gastropoda

(Fig. 1)

Certain small shells have similarities to both the *Orbiculoidea* and to the *Gastropods*, but no diagnostic characters have been noted and it is thought better not to assign any specific name as long as the generic name is in doubt.

Shell moderately elevated, conical, and subtrilobate in form, subequidimensional, slopes moderately steep and concave near the beak but slightly convex toward the margins. Beak pointed, erect, subcentral or slightly nearer one margin than the other. The three coalesced sub-hemiconical lobes formed by three shallow depressions about sixty degrees apart extending from the

¹ Published by permission of the chief geologist of The Pure Oil Company.

beak to the margin. Surface smooth except for numerous fine concentric lines. Internal characters not observed. Measurements of one individual: length 5.0 mm., width 5.5 mm. Measurements of second individual; length 4.5 mm., width 4.8 mm.

Remarks.—These specimens are variable in the distinctness of the three lobes and the depth of the three depressions between them as well as in the convexity of the slopes and to a less degree the position of the beak. They differ from *Crania?* cf. *Transversa* in being more conical, elevated, trilobate, and in lacking the straight posterior margin of the species. They differ from *Crania siluriana* in having concave slopes and a smooth surface. The shells are much like the illustrations of *Discina* (Orbiculoidea) *Plicosa*, Barrande, in the trilobation, the outline, and the sub-central or slightly eccentric positions of the beak. However these specimens are steeper and more pointed than *Plicosa*. Barrande shows a fissure in one of his illustrations while the specimens here described have shown none. The specimens are also similar to some of the simple forms of Cephalopods but they are less circular in outline, less inflated and with a smaller more pointed beak than the cephalopod pictures by Barrande in volume four, part one of his Silurian System.

Crania? cf. transversa, Barrande

(Fig. 2)

Pedicle valve attached to objects and taking much of the shape of the surface to which it adheres. *Brachial valve* depressed, subconical, wider than long with a subelliptical outline having a straight posterior margin which is considerably shorter than the greatest width of the valve. Valve moderately convex, with small beak inclined posteriorly and located about one-third the distance from the straight posterior hinge to the curved anterior margin, this position permitting the anterior and lateral slopes to be regular and gentle and the posterior slope triangular in shape and moderately steep. Surface smooth except for numerous fine concentric lines. Internal characters not preserved in these specimens. Measurements of one individual: length 6.0 mm.,

width 9.0 mm. Measurements of another individual; length 7.1 mm., width 8.3 mm.

Remarks.—These specimens are variable in elevation, and convexity but have general similarity in the position of the beak one-third the distance from the posterior margin, the posterior inclination of the subconical beak, and the presence of a straight posterior margin to the shell. The shells differ from *Siluriana* in being smoother and less rugose and in having a straight posterior margin. The larger specimens correspond in general to the illustrations of *Discina transversa*, Barrande, in general shape, convexity, position of the beak and shape and character of the posterior slopes. The posterior margin appears to be more nearly straight than that of *Transversa*. Whether *Transversa* is a *Crania* is a question not answered by the illustrations and there is nothing in Barrande's monograph to show that it is a true *Discina*. On the other hand there are only exterior characters to indicate that the St. Clair forms belong to the genus *Crania* and these alone are not conclusive.

II. PROTREMATA

Orthostrophia (*Schizoramma*-Foerste), Hall

The sub-genus *Schizoramma* is described as follows by A. F. Foerste:

"For the group of shells having the structure of *Hebertella fissistriata*, with number of intercalated striae, with the brachial valve not exceeding the pedicle valve in convexity, but externally resembling *Hebertella*, the term *Schizonema* (*Schizoramma*) is suggested. This term should include apparently also *Orthis fasciata*, Hall, which is not a true *Orthostrophia*, and possibly also *Orthis fissiplica*, Roemer."²

Several *Orthis* have been reported from the St. Clair Limestone but in making this collection *Rhipidomella hybrida* has not been found and in fact no specimens of that genus were collected, no *Orthis rugaplicata* was found and no true *Orthis*, and likewise no *Plectorthis jamesi* or any specimen belonging certainly to that

² Jour. Sci. Labs. Denison Univ., 14, 77, (1909).

genus. *Orthostrophia* (*Schizoramma*) *nisis* was not found, but four types which seem to be closely related—if not belonging to that genus—are described below.

Orthostrophia? (*Schizoramma*) *clairensa*, novum

(Fig. 3)

Pedicle valve moderately convex except for an ill-defined sinus which is not always present in young specimens but extends more than half the length of the mature shells. Shell wider than long, umbo convex, beak only slightly protuberant. Surface of the shell marked by subequal radiating costae which bifurcate, occurring in pairs or forming bundles to a limited extent. A few concentric lines of growth are present. Cardinal area concave, straight, narrow, almost as long as the greatest width of the shell, delthyrium moderately large, triangular, open. Interior of the valve with two dome-like dental supports and dental lamellae diverging about 30 degrees from each other. *Brachial valve* with convexity equal to or only slightly greater than the opposite valve. Fold ill-defined and only apparent on the anterior portion of the shell. Umbo not inflated, beak not protuberant, cardinal area extremely narrow. Measurement of one individual: length 16 mm., width 23 mm., width of cardinal area 2.5 mm., number of costae per 5 mm. at 5 mm. from beak, 15. Measurement of second individual: length 9.0 mm., width 13.1 mm., width of cardinal area 1.0 mm., number of costae per 5 mm. at 5 mm. from beak, 15. Measurement of third individual: length 13.3 mm., width 19.5 mm., width of cardinal area 2.7 mm., number of costae per 5 mm. at 5 mm. from beak, 13.

Remarks.—There is not sufficient evidence to place the four types of shells listed as *Orthostrophia* (*Schizoramma*) in that genus and they are referred to it on external characters, since the writer is unable to interpret the one incomplete internal impression which he has been able to procure as belonging to any certain genus. The specimens vary in convexity, the shape of the fold and sinus, and in the character of the plications. This is the

most abundant of the Orthids in the St. Clair Limestone. The species described above is larger than *Orthostrophia?* (*Schizoramma*) of *Fissiplicata* and has more uniform costae, not alternate in size. It differs from *Orthostrophia* (*Schizoramma*) *delicada* in being more convex. It differs from *Orthostrophia* (*Schizoramma*) *rama* in being larger, having coarser costae and having a longer hinge line and a more definite fold and sinus. It resembles *Hebertella tenax* from the Sexton Creek formation of Missouri but has finer costae, and is relatively broader.

Orthostrophia? cf. *Fissiplica*, Foerste

(Fig. 4)

Pedicle valve moderately convex except for a faint anterior flattening in place of a sinus. Shell wider than long, umbo convex but not inflated, beak but slightly protuberant. Surface of shell marked by alternating large and small costae, or by costae of various sizes in bundles. A few concentric lines of growth are present. Cardinal area straight, concave, narrow, almost equal to the greatest width of the shell, delthyrium moderately large, triangular, open. *Brachial valve* with convexity about equal to that of the opposite valve and with a very ill-defined indistinct fold. Umbo not inflated, beak slightly protuberant. Measurement of one individual: length 8.0 mm., width 11.0 mm., number costae per 5 mm. at 5 mm. from beak, 10. Measurement of second individual: length 5.2 mm., width 8.5 mm., number costae per 5 mm. at 5 mm. from beak, 11.

Remarks.—This type differs from *Orthostrophia?* (*Schizoramma*) *clairensa* in its smaller size, and in the varying differences in the size of the costae. It differs from *Orthostrophia?* (*Schizoramma*) *delicada* in being more convex, and in having coarser costae. It differs from *Orthostrophia?* (*Schizoramma*) *rama* in being less convex, having coarser plications and a longer hinge line. It is similar to *Hebertella fissiplicata roemer* and should be compared to that species at least until more is known about internal characters.

Orthostrophia? (Schizoramma) delicada, novum

(Fig. 5)

Pedicle valve subplano or gently convex, with an ill-defined, indistinct sinus on the anterior half of the valve. Shell wider than long, umbo slightly convex but not inflated, beak scarcely protuberant. Surface of the shell marked by fasciculate costae of varying sizes made by the bifurcating of the primary costae which originate along the posterior margin of the valve. Only a few lines of growth, and in some specimens none. Cardinal area straight, very narrow, almost equal to the greatest width of the shell. *Brachial valve* practically flat, or slightly convex, without apparent fold, umbo not inflated, and beak not protuberant. Measurements of one individual: length 10.2 mm., width 17.0 mm., number of costae per 5 mm. at 5 mm. from beak, 20. Measurements of second individual: length 10.0 mm., width 14.0 mm., number of costae per 5 mm. at 5 mm. from beak, 19.

Remarks.—This species differs from *Orthostrophia? (Schizoramma) clairensa* and cf. *fissiplicata* and *rama* in being subplano in form.

Orthostrophia? (Schizoramma) rama, novum

(Fig. 6)

Pedicle valve convex with greater convexity longitudinally than laterally, without sinus or with only a faint indication of one. Shell sub-ovate in outline, wider than long, hinge line considerably shorter than the greatest width of the shell. Beak scarcely protuberant. Surface of the shell marked by fine, bifurcating, fasciculate costae, a few costae being stronger and a number being weak, and these give the shell a characteristic ornamentation. Cardinal area narrow, delthyrium not observed. *Brachial valve* similar to the pedicle valve in convexity without fold or with merely a faint indication of one. Beak not protuberant, cardinal area extremely narrow. Measurement of one individual: length 5.8 mm., width 10.1 mm., number costae in 5 mm. at 5 mm. from the beak, 30. Measurement of second individual: length

7.0 mm., width 10.6 mm., number costae in 5 mm. at 5 mm. from the beak, 27.

Remarks.—This species differs from *Orthostrophia*? (*Schizoramma*) *clairensa* and cf. *fissiplicata* and *delicada* in its greater convexity, the shorter hinge line, and the more elliptical outline, and in the peculiar fasciculate arrangement of the costae. Its costae are also finer.

Dalmanella cf. *elegantula*, Dalman

(Fig. 7)

Shell planoconvex, length greater than the width; pedicle valve strongly convex and gibbous, arching over the cardinal area; brachial valve flat or slightly concave and with a shallow sinus, hinge line shorter than the greatest width of the shell; cardinal extremities somewhat rounded. Surface of both valves punctate, marked by faint radiating striae, shell substance finely fibrous. *Pedicle valve* strongly convex, greatest convexity on the umbo and along the ill-defined but fairly high ridge-like fold which makes up a very considerable part of the valve. Lateral slopes steep, their outer margins, especially the cardinal extremities, somewhat flattened. Anterior outline semi-circular. Beak rather prominent, protuberant, and up-curved and in-curved though not encroaching on the brachial valve. Cardinal area triangular, slightly concave, not extended but much shorter than the greatest width of the shell. *Brachial valve* flat or slightly concave, anterior and lateral margins semi-circular in outline. The flanks of the valve slope gently toward the shallow, ill-defined sinus and forward toward the anterior margin. Umbo slightly convex, cardinal extremities of the valve slope gently outward and backward to the hinge line. Cardinal area extremely narrow. Internal characters not found. Measurements of one individual: length 11.2 mm., width 9.7 mm., thickness 4.9 mm. Measurements of second individual: length 7.0 mm., width 6.3 mm., thickness 3.0 mm. (approx).

Remarks.—The specimens at hand are imperfect, one showing only the pedicle valve and the other having both valves with a

very imperfect cardinal area. They compare well with *elegantula* in anterior outline, in plano-convexity, and in having a high but indefinite median ridge on the pedicle valve, but they differ in being more pointed anteriorly and in being more elongate in form. Since the specimens are poorly preserved and since *Dalmanella elegantula* is quite variable it seems best to refer these fossils to that species. The specimens differ from *Arcuaria*, *Edgewoodensis*, *Lunata* and *Loveni* in having a flat brachial valve. They differ from *Modesta* in having many more and finer striae and in being more convex. They differ from *Dalmanella proxima*, Ball, in being more convex, more elongate, and in having a more elevated fold on the pedicle valve. They differ from *Dalmanella* (of the pisocrinus zone) of the Bainbridge, being described by Dr. Ball, in being more elongate and in lacking the slight furrow on the pedicle fold and in having much finer striations.

Plectambonites quinquecostate, McCoy

(Fig. 8)

Shell small, concave-convex, anterior margin semicircular, posterior border straight and equal to or nearly equal to the greatest width of the shell, cardinal extremities rounded or slightly submucronate. Surface of both valves marked by three, four, five or seven principal, thread-like, equidistant, rounded, radiating plications, between which fine, closely crowded striations make up the ornamentation. Occasionally a shorter rib occupies the middle of the interspaces between the principal plications but as such it extends only a short distance from the anterior margin. Surface sparsely punctate. *Pedicle valve* convex, strongly arched from front to back, greatest convexity in the umbonal region, slightly flattened toward the sides and especially at the cardinal extremities. Beak small, in-curved, slightly protuberant. Area triangular, moderately wide, long delthyrium partly closed by triangular plate and by the cardinal process of the other valve. *Brachial valve* concave, conforming to the opposite valve, cardinal area very narrow, umbonal region not inflated or protuberant over the cardinal area. Interior not observed. Measurements of

one individual: length 4.0 mm., width 7.2 mm., thickness 1.4 mm. Measurements of second individual: length 4.7 mm., width 7.3 mm., thickness 2.1 mm.

Remarks.—These specimens closely simulate the description and figures of the European forms included under this species. The type agrees with the British specimens in bearing "much resemblance to *Leptaena segmentum*, but is distinguished exteriorly by its smaller number of principal radii, which in most specimens do not exceed five. Its beak is also larger and more projecting than in *Leptaena segmentum*. Prof. McCoy remarks that the internal cast of the ventral valve presents a very short mesial septum, dividing the small, tumid, reniform pair of muscular impressions, reaching only one-fifth the length of the shell; that from these, five or six, slender, branched impressions of the pallial vessels extend on each side to the margin, a broad border round which is very minutely and closely punctured under the lens, the rest of the cast being nearly smooth."³ *Plectambonites transversalis prolongatus*, *Plectambonites sericeus* and *intermedius* are reported from the St. Clair Limestone and may belong to the species described above. The markings are not those of *transversalis* and neither the markings or the deep convexity of *sericeus*. Many specimens lacking the distinctive linear ornamentation are referred to *Quinquecostata* since they appear to be shells having the outer covering destroyed, and this is proved in part at least by specimens which have part of the outer covering removed and revealing the fibrous under layers which are characteristic of the shells without striations. The species is common in the formation but may not be said to be abundantly represented.

Leptaena rhomboidalis, Wilckens

(Fig. 9)

Shell sub-semi-circular or sub-quadrate in outline, hinge line straight and forming the greatest width of the shell, both valves flat, except around the lateral and anterior borders where they slope down steeply, the two valves fitting much as two pans of

³ Davidson, Brit. Fossil Brachiopods III, 322-323, (1864).

similar shape fit into each other. *Pedicle valve* made up of a rather large flat, backward sloping area surrounded anteriorly and laterally by the last and most elevated concentric wrinkle in front of which the shell is bent abruptly and almost vertically down toward the other valve. Very slightly convex near the beak. The whole valve marked by coarse radiating striae, and the flattened portions marked by a large number of concentric wrinkles which are in many cases discontinuous and bend outward toward the cardinal extremities as they near the cardinal margin. The geniculate character and the roughness of the wrinkles become more marked with age. Beak small, not incurved, with a small circular perforation. Cardinal area long and narrow, none of the specimens show it well enough for the delthyrium to be described. *Brachial valve* concave, bent abruptly upward toward the anterior and lateral margins to conform to the pedicle valve, posterior part flattened and marked with concentric wrinkles and coarse radiating striae similar to those of the pedicle valve. Measurements of one individual: length 8 mm., width 12 mm. Measurements of second individual: length 8 mm., width 14 mm.

Remarks.—All of the St. Clair specimens are small, but they conform to the general characteristics of the groups included under the name *Leptaena rhomboidalis*.

Triplecia contrarius, Barrande

(Fig. 10)

Pedicle valve strongly convex with the flanks sloping down to the lateral margins, a rounded median sinus extending through the anterior half of the shell and widening and deepening as it approaches the anterior margin. Width of the shell greater than the length, surface smooth except for a few inconspicuous lines of growth. Umbo slightly inflated, beak pointed, protuberant but not extending far beyond the outward sloping cardinal area, foramen small, circular and apical. Cardinal area triangular, broad, slightly concave, length of area much less than the greatest width of shell. Delthyrium not observed but probably covered, the covering being coalesced with the cardinal area. *Brachial*

valve not found. Measurements of one specimen: length 4.0 mm. approximately, width 5.4 mm.

Remarks.—Only one specimen has been collected by the writer but it is very close if not identical with *M. contrarius* of Barrande and it is here described as *T. contrarius* because the fold and sinus are reversed from a true *Mimulus*, *M. perversus* being the type of that genus. It differs from *Triplecia waldronensis* in being regular and symmetrical in form and in having a cardinal area which is shorter than the greatest width of the shell. It differs from *Triplecia orton*i in having a high cardinal area, and inconspicuous delthyrium, and a sinus extending only about half the length of the shell. Specimens of *T. orton*i in the collection of Walker Museum are much larger, a nearly complete one being about 20 mm. long and 24 mm. wide.

Mimulus, Barrande

Generic characters.—Shell biconvex, sub-pentagonal in outline, non-plicate, with a well developed fold in the pedicle valve, and sinus in the brachial valve. Cardinal area of pedicle valve of moderate size, sharply defined, and with no superficial evidence of a delthyrium. The internal features of the valves unknown. The genotype of Barrande's *Mimulus* is the Species *M. perversus* in which the fold is in the pedicle valve and the sinus in the brachial valve. He describes two other species *M. moera* and *M. contrarius* having the same general outline with similar cardinal area and delthyrium, but with the fold and sinus reversed, that is the fold on the brachial valve and the sinus on the pedicle valve.⁴ *M. waldronensis*, an American species, has been referred to this genus, but this too has the fold and sinus reversed from the condition in the genotype. The reversal of the fold and sinus in relation to the two valves seems to the writer to be of sufficient importance to warrant the recognition of two generic types. The name *Mimulus* should be retained for the species *M. perversus* and such others which exhibit the fold in the pedicle valve and the sinus in the brachial valve. With this restriction the

⁴ Barrande, J-System Silurien, V.

genus *Mimulus* seems essentially to be a *Triplexia* with the relations of the fold and sinus reversed, so that Barrande's two species *M. moera* and *M. contrarius* may perhaps be properly referred to the genus *Triplexia*.

Mimulus perversus, Barrande

(Fig. 11)

Pedicle valve convex with an ill defined fold extending from the beak to the anterior margin, the fold having little curvature longitudinally but sloping steeply toward both flanks, especially toward the anterior flanks where two short depressions or sinuses, one on either side of the fold, cause the anterior part of the fold to stand in high relief. Width of the valve greater than the length, surface smooth. Beak pointed, protuberant, but not extending far beyond the outward sloping cardinal area; foramen circular and apical. Cardinal area triangular, slightly concave, height almost equal to one half of length of the hinge line; hinge line straight and approximately equal to one third width of shell. Delthyrium not observed but probably covered, the covering being coalesced with the cardinal area. *Brachial valve* strongly convex, greatest convexity at the umbo where there is a marked inflation extending about half the length of the valve. In front of this inflation is an ill-defined broad rounded sinus extending to the anterior margin causing the valve to mortice with the fold of the pedicle valve. Surface smooth except for very faint lines of growth. Internal characters unknown. Measurements of one shell: length 6.5 mm. width 7.2 mm., thickness 4.7 mm.

Remarks.—This little shell has been identified with Barrande's Bohemian species *M. perversus* from the stage E2. No authentic Bohemian species have been available for comparison, but the Arkansas specimens agree so closely with the illustrations that it seems inadvisable to separate them from the species illustrated. The only feature in which the American examples differ from the Bohemian is in the somewhat shorter fold and sinus. Where preserved as single valves separation from other genera such as *Clorinda* is difficult and often impossible, but where both valves with well preserved beaks are seen they are noted to be distinct.

Streptis grayii, Davidson 1881

The genus *Streptis* is described by Davidson in *The Monograph of British Brachiopoda* of the British Paleontological Society and in the *Supplement* to the *British Silurian Brachiopoda*. The shell is small, strongly convex, lacking bilateral symmetry but having one side of the valve more elevated than the other, and having a curved sinus. The beak of the pedicle valve is small, in-curved, with a small apical foramen which is separated from the hinge line by a narrow triangular deltidium. Surface marked by rough, ridge-like concentric lines of growth. Internal characters unknown, and according to Davidson with "no calcareous support for the labial appendages; cardinal process much produced, hinge-teeth large and prominent." The genus is placed by Schuchert with the Tripleciinae of the Strophomenacea in the revision of Zittel's *Textbook of Palaeontology*. *Pedicle valve* of the St. Clair specimens sub-oval in outline, strongly convex, irregular in contour, and sharply twisted in appearance, with one side of the shell more elevated than the other, and these parts separated by a rounded sinus which extends in a curve from the umbo to the anterior margin. Beak slightly inflated, moderately protuberant and incurved, probably pierced by a circular foramen although this opening and the characters of the hinge line are not clearly shown on the two specimens collected. Surface marked by strong, ridge-like concentric lines of growth which have short longitudinal laminations giving the shell a shingled appearance. Internal characters not observed. *Brachial valve* not collected. Measurement of one individual: length 3.6 mm., width 5.7 mm. Measurement of second individual: length 1.7 mm., width 2.8 mm.

Remarks.—*Streptis grayii* has been described from the Wenlock Limestone of Britain, and from the Silurian of Gotland and Bohemia.

PLATE XXXVI

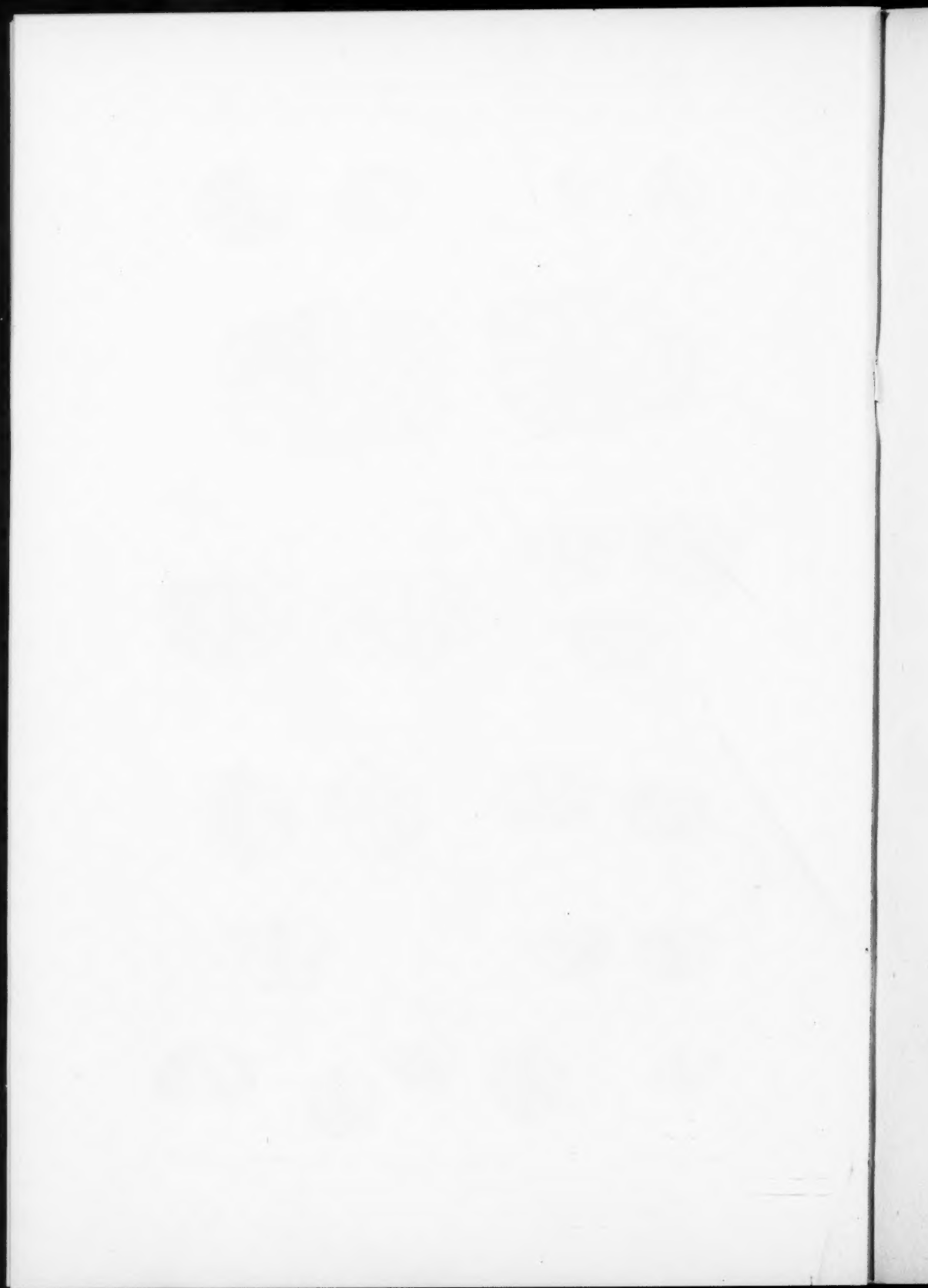
SOME ST. CLAIR ATREMATA AND PROTREMATA

- Fig. 1. *Orbiculoidea* or *gastropoda*. Two specimens.
Fig. 2. *Crania?* cf. *transversa*, Barrande. Brachial valve.
Fig. 3. *Orthostrophia clairensa*, novum. Left-pedicle, Right brachial.
Fig. 4. *Orthostrophia* cf. *fissiplicata*, Foerste. Left pedicle, Right brachial.
Lower pedicle.
Fig. 5. *Orthostrophia delicada*, novum. Two specimens.
Fig. 6. *Orthostrophia rama*, novum. Two brachial valves.
Fig. 7. *Dalmanella* cf. *elegantula*, Dalman. Left pedicle. Right brachial.
Fig. 8. *Plectambonites quinquecostata*, McCoy. Left pedicle. Right brachial.
Fig. 9. *Leptaena rhomboidalis*, Wilkens. Pedicle valve.
Fig. 10. *Triplecia contrarius*, Barrande. Pedicle valve.
Fig. 11. *Mimulus perversus*, Barrande. Left pedicle, Center cardinal, Right brachial.
Fig. 12. *Streptis grayii*, Davidson. Pedicle valve.



NORMAN L. THOMAS

BRACHIOPODS FROM ST. CLAIR LIMESTONE, ARKANSAS



THE PHYTOSAURIA OF THE WYOMING TRIASSIC

M. G. MEHL

Received May 16, 1928; Published August 9, 1928

The earliest recorded finds of identifiable phytosaur remains in Wyoming are those described by Williston in 1904.¹ These materials consist chiefly of three skulls with some associated skeletal parts. One of the skulls (with part of the lower jaw) was considered generically distinct by Williston and described as *Paleorhinus bransoni*.²

In 1913 Mehl gave a preliminary description³ of two other skulls referred to by Williston in the notice of *P. bransoni*. The larger of these was designated as the type of a new genus and species, *Angistorhinus grandis*, and the smaller skull as probably representing another species of the same genus. In a latter paper⁴ Mehl described the two skulls more fully as *A. grandis* and *A. gracilis*. The description includes the mandibles of both forms, a vertebra and the ventral ribs of *A. gracilis*, and numerous teeth, supposedly of the genus *Angistorhinus*. A fourth skull was mentioned by Williston⁵ in his notice of *P. bransoni*. Dr. E. B. Branson, who found the specimen, informs the writer that this skull undoubtedly belonged with the remains described by Williston as *Dolichobrachium gracile*.⁶ Williston's notes on this skull were made before it was completely exposed. It was very poorly preserved and when examined in the laboratory was reduced almost to powder.

¹ S. W. Williston; Notice of some new reptiles from the Upper Trias of Wyoming; Jour. Geol., 12, 696-697 (1904).

² Op. cit., 696.

³ M. G. Mehl; *Angistorhinus*, a new genus of Phytosauria from the Trias of Wyoming; Jour. Geol., 21, 186-191 (1913).

⁴ M. G. Mehl; The Phytosauria of the Trias; Jour. Geol., 23, 129-165 (1915)

⁵ Op. cit., p. 697.

⁶ Op. cit., p. 688.

Since these earlier finds, fragmentary phytosaur remains have been collected in Wyoming from time to time, but no further light has been thrown on the genera, *Paleorhinus* and *Angistorhinus*. Both are inadequately known and have not been identified with certainty outside of the Wyoming Trias. Mehl described a slender mandibular ramus of a phytosaur from Arizona and referred it with question to the genus *Angistorhinus*.⁷ Toepelman described the rostrum of a small phytosaur skull from New Mexico and suggested that it might belong to the genus *Paleorhinus*.⁸

Both of these references were unfortunate in that the uncertainty of the generic reference has been ignored by writers dealing with the problems of Triassic stratigraphy. As a result, lists of Triassic vertebrate genera and their distribution are likely to be misleading.

During the summer of 1927 the University of Missouri geological field party, working in west-central Wyoming, added numerous phytosaur remains of a varied nature to the University of Missouri vertebrate paleontology collection. It now seems possible to clear up several doubtful points in the anatomy of the genera occurring in Wyoming. Even more important, perhaps, is the confirmation given by the new material to some of the earlier observations on these forms.

PALEORHINUS PARVUS, NEW SP.

The material on which this species is based consists of part of the left half of a skull and mandible, the essentials of the pectoral and pelvic girdles, the propodials and epipodials, and a few fragments from other parts of the skeleton. The side of the skull preserved is complete from the tip of the rostrum to about mid-length of the antorbital opening and includes most of the teeth. The short length of the skull preserved back of the nares is broken and twisted, but apparently should have an attitude much like that shown in the accompanying sketch, figure 1.

⁷ M. G. Mehl; New or little known phytosaurs from Arizona; Bull. Univ. Oklahoma, n. s. No. 103, University Studies Series No. 5, 26-28 (1916).

⁸ Walter C. Toepelman; Phytosaur remains from New Mexico; Bull. Univ. Oklahoma, n. s. No. 103, University Studies Series No. 5, 40-44 (1916).

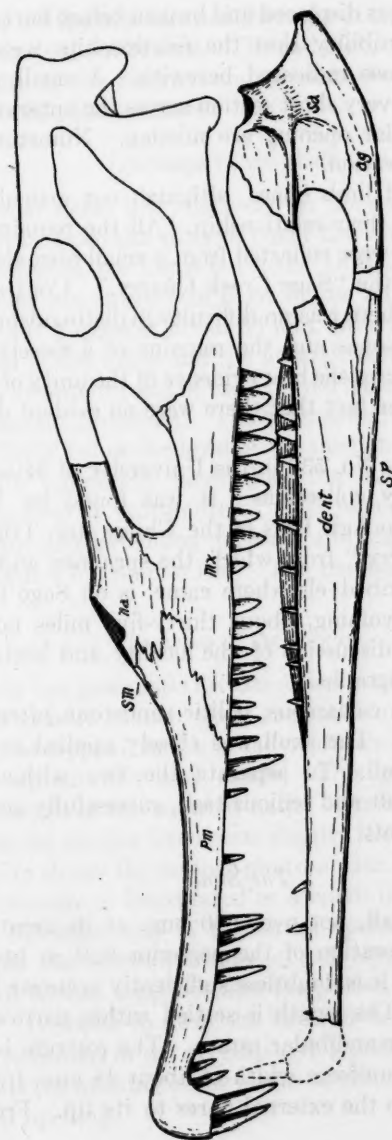


FIG. 1. PALEORHINUS PARVUS; LEFT LATERAL VIEW OF SKULL AND MANDIBLE
One-fourth natural size

The mandible was displaced and broken before burial, but there is only slight possibility that the relationships were markedly different from those indicated herewith. A small part of the anterior tip and a very short section across the anterior end of the external mandibular opening are missing. Numerous teeth lie in their normal position.

The girdles and limb bones, although not articulated, leave little doubt as to their relationship. All the remains described under this species were collected from a small area along a single bedding plane in the "Sage Creek Quarry." Contrary to what was anticipated, there was no difficulty in distinguishing between these phytosaur bones and the remains of a closely associated amphibian. Perhaps the best evidence of the unity of this phytosaur material is the fact that there were no evident duplications of skeletal parts.

This specimen is No. 530 in the University of Missouri vertebrate paleontology collections. It was found by Mr. N. H. Brown in the Popo Agie beds of the Chugwater, Triassic. The "Sage Creek Quarry," from which the specimen and other materials to be described elsewhere came, is on Sage Creek, Fremont County, Wyoming, about thirty-five miles northwest of Lander. A fuller discussion of the locality and horizon will be given in later paragraphs.

The matrix is a calcareous, oölitic sandstone, often very hard next to the bone. The skull was closely applied to a delicate stegocephalian skull. To separate the two without injuring either was a difficult and tedious task, successfully accomplished by Mr. Vernon Scott.

The Skull

The skull is small, not over 660 mm. at its greatest length. Although the restoration of the posterior half as here given is merely suggestive, it is doubtless sufficiently accurate for proportion characters. The length is settled within narrow limits by the length of the mandibular ramus. The rostrum is relatively slender, having a uniform width of about 48 mm. from a point slightly anterior to the external nares to its tip. From the an-

terior end of the maxilla forward throughout its length the depth of the rostrum is about 24 mm. The end is abruptly down-curved at right angles to the rostrum and extends about 24 mm. below the plane of the palate surface.

Openings in the skull

The external nares are relatively far forward, their anterior border 280 mm. from the anterior tip of the skull. Although the posterior border of the nares is broken away, it is evident that these openings are entirely in front of the antorbital fenestrae. It is likely that a space of about 35 mm. intervened between the posterior end of the nares and the anterior end of the antorbital opening. The anterior end of the external narial opening is somewhat slit-like and ill-defined. The outer margin, as viewed laterally, is distinctly below the level of the median septum.

Apparently something more than the anterior half of the *antorbital opening* is represented. It is regularly oval in shape with the long axis extending forward and slightly down. The greatest length is 100 mm. or less. The maximum width is about 40 mm.

The bones of the dorsum

Apparently the *premaxilla* divides at the posterior end into two processes; a slender branch along the median line that extends into the narial septum, and a broader process reaching back beneath the *septomaxilla* and *nasals*. This process reaches to about mid-length of the external narial opening. The posterior extent along the median line seems slightly less.

The *maxilla* shows the normal phytosaurian development.

The *septomaxilla* is interpreted as a small bone forming thin lamella on the inner side of the narial opening and extending forward from the anterior border of this opening as a narrow wedge, about 25 mm. long, between the posterior branches of the *premaxilla*. It seems to form the anterior border of the narial opening as indicated in the accompanying sketch, figure 2A, and thus prevents the meeting of the *nasals* at the median line in front of the narial opening.

The *nasal* boundaries are not determinable except at the anterior end as indicated above. It is possible that this element takes part in the upper border of the antorbital vacuity. The relatively long space between the orbit and nares requires an exceptional lengthening of some of the intervening bones, but there is no direct evidence of the relationship of the narial as here suggested.

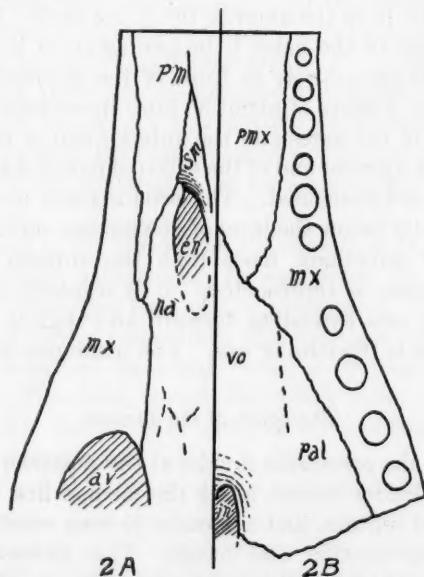


FIG. 2. PALEORHINUS PARVUS; DORSAL AND PALATE VIEW OF PART OF LEFT HALF OF SKULL ABOUT NARIAL REGION COMPARED

Av, antorbital vacuity; *en*, external nares; *in*, internal nares; *mx*, maxilla; *na*, nasal; *pal*, palatine; *pm*, premaxilla, *pmx*, premaxilla; *sm* septomaxilla. Figures one-half natural size.

The palate

A short section of the palate, as shown in figure 2B, is available for study. Apparently the alveolar ridges, conspicuous in the type of *P. bransoni*, are little developed. The sutures cannot be determined with certainty except those of the premaxilla and

maxilla. There is meager evidence of a broad vomer of considerable length in front of the internal nares, restricting the anterior ends of the palatine to a slender wedge. A comparison of A and B of figure 2 shows the position of the external and internal nares. The small part of the narial vault preserved suggests that there was but a slight arching here above the general palate surface.

The mandible

The position of the sections of the mandible preserved is determined in part by a comparison of its teeth with those of the upper jaw, inasmuch as the posterior part of the skull is missing. With the dentary placed so that the posterior tooth is slightly back of the maxilla series there is left just enough space at the anterior end of the mandible for the addition of a slightly expanded terminus to accommodate a large tooth, one or more of which are always present at the anterior end of the dentary of the phytosaurs. A greater anterior extension than that shown in the accompanying restoration would fail to close behind the terminal teeth of the downturned rostrum. Even with this slight addition to the anterior end, the conical teeth of the mandible impinge on the "slicing" teeth of the upper jaw. There seems to be but a slight gap across the external mandibular opening. An increase of this gap would necessitate the elongation of the cranium out of proportion, if one may judge by similar known forms. Thus restored, the mandible has a length of 644 mm. The symphysis unites the rami for a distance of 264 mm. At the anterior end of the ramus, just back of what is likely the terminal expansion, the depth is 22 mm.

The external mandibular opening is 33 mm. high and is apparently exceptionally short, very likely not more than 84 mm. Other measurements are of little value because the ramus has been laterally compressed back of the symphysis.

The determinable sutures are indicated in the accompanying drawing. There is little to suggest the characteristic alveolar ridge of phytosaurs unless the parapet described below is so interpreted.

One of the striking peculiarities of the mandible is a thin parapet along the inner side of the alveolar margin. It originates slightly back of the posterior tooth and extends forward well into the symphysis where it thickens to a broadly rounded elevation extending to the median line. At mid-length it rises 15 mm. above the outer alveolar margin.

The dentition

The specimen is remarkable in the number of teeth preserved. In the down-turned tip of the rostrum the premaxilla bears two teeth of superior size. At their bases they are 10 mm. in diameter and circular in section. They are 45 mm. long and directed down and slightly backward. Only the second is well enough preserved for detailed description. From one-third its length above the base to the tip it shows a slight lateral compression. On the posterior side of the compressed part there is a faint, sharp, crenulated ridge which reaches to the tip of the tooth. A similar edge is evident for a short distance at the tip of the anterior side.

The following premaxillary teeth appear to be circular in cross section throughout the length of the series. In length they vary from 10 mm. to 33 mm. with corresponding variations in diameters. There is no evident arrangement according to size except in the first three back of the down-turned tip. Here the size is limited by the terminal tooth or teeth of the mandible as is indicated later. The presence of small teeth in large alveolae gives evidence that replacement was the determining factor in size. When a large tooth was lost the tooth that moved out to fill the space was conspicuously smaller than adjacent teeth.

All the premaxilla alveolae are distinct with intervening spaces of irregular width. There are twelve teeth preserved in the premaxilla and evident positions of four more. Most likely the series contained eighteen to twenty. It has been impossible to free the matrix from the entire length of the alveolar margin.

The maxilla contains seventeen teeth divided into seizing teeth in front and slicing teeth behind. The anterior teeth are round in cross section and comparatively slender and pointed. The first seven are perceptibly fluted.

The next few teeth are transitional to the distinctly slicing type of which the posterior five are typical. The latter group varies from 10 to 15 mm. in length. All are compressed laterally, a condition that is slightly evident even in the roots. Although both anterior and posterior sides are produced into sharp, finely crenulated edges, the anterior side is more broadly rounded and the "cutting edge" less conspicuous.

At about mid-length of the series is a space of 12 mm. between adjacent teeth, a much greater interval than in any other part of the jaw. A slight scar along the alveolar margin suggests that a tooth in this space had reached its limit of replacement and that the alveolus had finally filled with bony tissue. This evidence is in keeping with other points indicative of an adult individual. None of the teeth shows evidence of wear, a fact that probably bespeaks the thoroughness of replacement as much as it does a soft diet or immaturity.

The tooth series of the mandible, although not so nearly complete as that of the upper jaw, is sufficient to indicate the nature of the lower dentition.

Excepting the terminal tooth, most likely none of the mandibular set was comparable in size to the upper dentition as a whole. Of those preserved the largest, 15 mm. long, is a slender cone well toward the posterior end. Only the teeth of the anterior half of the series could have been functional in any real sense. Those of the posterior half barely reach the top of the bony parapet along the inner side of the alveolae against which the teeth are closely crowded.

The four teeth preserved at the posterior end of the series are of the slicing type, i.e., laterally compressed with anterior and posterior finely serrated, cutting edges. The terminus is restored with a single large tooth which evidently closed on the outer side of the rostrum. At the laterally restricted region back of the down-turned tip of the rostrum, the arrangement of the premaxilla teeth seems to have permitted this. There is scarcely space for two large terminal dentary teeth, as is often the case in the phytosaurs.

The vertebral column

Little can be determined concerning the vertebral column. Numerous vertebrae were found weathered out on the slope near the quarry but lack of definite association and poor preservation make most of this material of little value. A single neural arch from the anterior thoracic series is definitely associated with the skull and limb-bones. Considering the age of the animal suggested by the teeth, as noted above, and the perfection of the articular faces of the limb-bones, as noted later, the separate arch seems to indicate that arches and centra failed to unite solidly in this species. The essentials of the arch are adequately shown in plate XXXIX, fig. 1.

The shoulder girdle

The left *scapula* and *coracoid* and the lateral half of the left clavicle are preserved. The latter is too fragmentary to show characters of value.

The *scapula* is relatively delicate. The upper end is missing and there is nothing to indicate its length. The articulation for the *coracoid* is concave and sharply outlined. The posterolateral process, which normally forms a goodly part of the glenoid fossa, is slightly abraded in the specimen, but it is exceptionally small and indicates clearly that the *scapula* entered the glenoid fossa very slightly.

The *coracoid*, in keeping with the suggestion furnished by the *scapula*, seems to make up nearly the entire surface of the glenoid fossa. Although most of the inferior wing is broken away, a large notch is clearly indicated at its upper anterior border.

The humerus

The proximal end of the right and the proximal and distal ends of the left *humerus* are preserved. Apparently only a short section of the shaft of the left bone is missing and this has been restored after another *humerus* of similar proportions from Arizona. Except for a likely error in length as a result of this restoration all of the details are remarkably preserved.

The bone has a length of approximately 270 mm. The entire bone is dorso-ventrally flattened without evidence of crushing. At mid-length the shaft is oval in section with short and long axes of about 18 mm. and 27 mm. or even less. The proximal and distal ends are expanded to widths of 85 mm. and 82 mm. respectively. The planes of the expansions form an angle of about 25° with each other. The deltoid ridge, on the antero-ventral margin, starts at the proximal articulation and continues approximately one-third the length of the bone. The radial articulation is hemispherical and distinctly set off from the transversely elongate ulnar articulation by a broad, deep groove. On the under surface of the distal expansion is a deep excavation above the radial articulation and confluent with the groove that divides the distal end of the bone into ulnar and radial condyles. A delicate process from the thin ectepicondylar crest just fails to connect with the lower, anterior margin of the bone and it thus leaves a pronounced notch rather than an ectepicondylar foramen.

The radius

The radius is 152 mm. long. The shaft is slightly oval in cross section with greater and lesser diameters of 15 mm. and 11 mm. The distal end is expanded into a circular, convex face 21 mm. in diameter. The proximal articulation is 34 mm. antero-posteriorly and 20 mm. wide. It is markedly concave antero-posteriorly.

The ulna

The ulna, viewed from the inner side is S-shaped. It has a length of 178 mm. At its upper end it is 22 mm. thick and expanded antero-posteriorly to a width of 45 mm. Throughout most of its length it is markedly concave from side to side on the inner side of the bone, becoming spatulate at the distal extremity where its width and thickness are 35 mm. and 10 mm. respectively.

The pelvic girdle

The right *ilium* is well preserved except for the loss of the upper-posterior process. The bone seems small and delicate in compari-

son with the femur, but there can be no doubt that the parts were associated in the same skeleton. The greatest height is 85 mm.; the greatest width, across the acetabulum at the articulation for the pubis and ischium, is 90 mm. The acetabulum, broad and shallow, is largely confined to the ilium. The supra-acetabular ridge, although pronounced, is not sharply set off from the general surface of the bone. The length of the pubic facet is 47 mm. The articulation for the ischium is 55 mm.

The *pubis* is 125 mm. long and, at its lower end, 100 mm. wide. Its iliac facet is distinctly set off from a small facet near the mid-width of the upper end of the pubis, that formed a small part of the acetabulum. The lower, antero-posteriorly expanded part is curved into a pronounced concavity of the outer surface such that only the posterior part of the lower margin could have united with the left pubis at the median line. In an anterior view the pubis was broadly flaring but did not extend below the general floor of the pelvis. There is a broad, deep pubic notch as indicated in figures 6 and 7, plate XXXVIII. The outline of this notch is preserved in the matrix. This, and the unbroken margin of the bone, eliminate the possibility of a pubic foramen rather than a notch.

The *ischium* is not preserved.

The femur

The femur is comparatively slender and delicate. It is 330 mm. long and at mid-length, where the cross section is circular, its diameter is about 35 mm. The shaft of the bone was hollow with walls averaging about 7 mm. in thickness.

The proximal end of the femur is flat and broadly expanded antero-posteriorly. In the plane of this expansion the bone is essentially straight. In a superior view, thus oriented, the femur is markedly S-shaped. The distal end lies in a plane that forms an angle of about 70° with that of the proximal end. The expansion of the proximal end is 80 mm. wide and that of the distal end but slightly less. On the ventral side, near the proximal end, the surface of the bone is distinctly off-set posteriorly to a depth of 9 mm. so as to form a sharp-edged shelf or ridge-like

trochanter 70 mm. long. The upper end of this trochanter starts at a point 65 mm. below the proximal end of the femur.

The tibia

The tibia is 205 mm. long and markedly curved inward and backward. Compared with the front leg bones, it is massive. At the proximal end it is roughly square in section with lateral and antero-posterior measurements of 53 mm. and 57 mm. respectively. At mid-length the essentially circular shaft is 28 mm. in diameter. The distal end is expanded into a slightly convex articular facet, oval in shape, 28 mm. antero-posteriorly and 42 mm. wide.

The fibula

The fibula is 183 mm. long with conspicuously curved shaft. The measurements of the proximal articulation are 37 mm. and 49 mm. The distal articulation measures 25 mm. and 39 mm. The shaft is triangular in section at mid-length; about 24 mm. in its greatest dimension.

A single mesopodial was associated with the material here described. The size and shape of the proximal articular facet suggests that it is the fibulare.

The armor

Although only a few dermal scutes were found associated with the specimen herein described, their nature is such that certain generalizations can be made concerning the dorsal armor of *Paleorhinus parvus*. All of the plates are small, varying in size from about 12 mm. to 50 mm. in diameter. Few if any of the plates are symmetrical although they are roughly circular in outline. The larger plates are as much as 10 mm. thick at the center but there is little to suggest a central node or keel. All are thin at the margins. The surface of the plates is minutely pitted and occasionally somewhat wrinkled. The under sides of the plates are smooth but not flat or regularly curved. They are irregularly warped as though for over-riding adjacent plates. On the upper side above some of the down-warped margins, the

surface is smooth and distinctly faceted for the reception, very likely, of a projection from an adjacent plate, as indicated in the accompanying photograph, figure 6, plate XXXVII.

There are no thickened, faceted margins to suggest the abutting of adjacent rows of plates as is the case in some of the phytosaurs. On the other hand, there is no evidence that the plates were isolated, in which case they would likely have a flattened or regularly curved underside and a fairly regular outline. The writer interprets the armor as an irregularly over-lapping covering of dermal plates presenting an unbroken bony surface of great flexibility.

Relation to Paleorhinus bransoni

Williston's original description of *Paleorhinus bransoni*⁹ is brief and, aside from some of the dimensions listed and the outline drawing, is lacking in a discussion of lesser characters. A more elaborate description of this specimen was presented by Lees at a later time.¹⁰ The outstanding characters listed by Lees are as follows:

"Skull greatly elongate, triangular; snout long, slender, depressed. External nares elevated, situated at posterior extremity of snout, entirely in front of antorbital vacuities, separated by downward extensions of nasals. Antorbital vacuities large; supratemporal vacuities small, completely enclosed; otic foramina present and completely enclosed. Quadrate foramina present, small. Squamosal extending but slightly beyond posterior margin of quadrate. . . . Plane of orbits directed obliquely upward.

"Internal nares situated posterior to external, separated by vomers. Palatines separated by pterygoids. Vomers long and slender, separating pterygoids throughout, extending back to presphenoidal opening. Pterygoids long, entering into posterior margin of nares between palatines and vomers, extending postero-laterally in broad vertical plates for union with quadrates. . . .

"Posterior palatine foramina small, wholly enclosed by palatines and transverses. Presphenoidal opening small, cordiform. Teeth thirty-six on each side of the upper jaw, two foremost larger and much elongate."

⁹ Op. cit., 696-697.

¹⁰ J. H. Lees; The skull of *Paleorhinus*; Jour. Geol., 25, 121-151 (1907).

The ilium figured and described by Lees¹¹ was shown to belong to a different form¹² and was later described as *Poposaurus gracilis*.¹³ For actual comparison of the two phytosaurs there is available then a limited number of characters of the skull and mandible. Measurements given by Williston are not entirely dependable because they were made before the skull of *P. bransoni* was prepared. Some of the measurements given by Lees are undoubtedly misleading because of marked crushing of the skull. Obviously such measurements as total length, length of the rostrum, etc., would be unaffected by this and were found to be essentially correct by the writer.

The close relationship of the form here described to *Paleorhinus bransoni* is evident. Both are comparatively small skulls with slender rostra; external nares considerably in advance of the internal openings; the external opening relatively far forward, near mid-length of the skull, and entirely anterior to the antorbital fenestrae. The number of teeth in the skulls of the two forms is apparently the same.

The form here described, *P. parvus*, has much the shorter rostrum; 280 mm. as compared with something over 390 mm. in *P. bransoni*. True, *P. bransoni* is a larger skull, having a length of about 780 mm. while *P. parvus* is approximately 660 mm. long. The dorsal post-narial length is essentially the same, however, as the specimen here described has been restored. As pointed out above, the length of the mandible determined the length of the restored part of the skull, and an appreciably lesser length of restoration is impossible.

The length of the rostrum then, seems to be an important difference. The rostrum of *P. parvus* is the more slender. It is 59 mm. wide across the anterior end of the external nares and 76 mm. in *P. bransoni* with corresponding differences to the tip of the rostrum. In the form here described, the tip of the rostrum is abruptly down-turned while in that of *P. bransoni* the terminal

¹¹ Op. cit., fig. 8.

¹² M. G. Mehl; The Phytosauria of the Trias; Jour. Geol., 23, 159-161 (1915).

¹³ M. G. Mehl; *Poposaurus Gracilis*, a new reptile from the Triassic of Wyoming; Jour. Geol., 23, 516-522 (1915).

curvature is less sharp and the tip extends forward and down. *P. parvus* seems to lack the alveolar ridges on the palate and mandible, characters conspicuous in *P. bransoni*. The difference in the development of the nasals as it has been described in the two forms is not dependable, as will be indicated later. For the same reason the development of the palate elements about the internal nares cannot be compared satisfactorily. Apparently the external mandibular fenestra of *P. bransoni* is considerably longer than *P. parvus*, but here again there is uncertainty.

There seem to be sufficient points of difference in the two skulls as noted above to establish their specific distinctness as here proposed.

Generic characteristics of Paleorhinus

Lees' description of *Paleorhinus bransoni* included numerous characters that are unique among phytosaurs. Among the more important of such features are the development of the posttemporal arcade at the level of the roof of the skull; the nasals meeting at the median line in front of the nares; a distinct otic opening; the posterior extension of the vomers to the interpterygoid vacuity; and a distinctly unphytosaurian ilium. Each of these points has been questioned, but, with the exception of the ilium which was shown to belong to another form,¹⁴ none has been settled conclusively. The development of the vomers was questioned by Jaekel¹⁵ who presented figures, without examining the specimen, of what he considered the logical interpretation. Case, perhaps through error, lists *Paleorhinus* as possessing a depressed posttemporal arcade.¹⁶

With these doubtful points in mind, the writer made a careful examination of the type of *P. bransoni* and expressed his observations at that time as follows:¹⁷

¹⁴ M. G. Mehl; Op. cit.

¹⁵ Otto Jaekel: Über einen neuen Belodonten aus dem Buntsandstein von Bernburg; Sitzungsberichten der Gesellschaft naturforschender Freunde, No. 5 (1910).

¹⁶ E. C. Case; New reptiles and stegocephalians from the upper Triassic of Western Texas; Carnegie Inst., Washington, Pub. No. 321, 68 (1922).

¹⁷ M. G. Mehl; The Phytosauria of the Trias; Jour. Geol., 22, 158-159 (1915).

"The skull is very much crushed, especially the palate, and few of the sutures are discernible. As the specimen is now prepared the articular face of the quadrate is turned almost directly outward instead of down, thus greatly exaggerating the posterior width of the skull. Basing the outline of a posterior view of *Palaeorhinus* on either *Mystriosuchus* or *Angistorhinus*, the greatest width would probably be not over 240 mm. in an uncrushed condition, or but little if any greater than that of *M. planirostrus*. In 1911, . . . Jaekel mentioned the peculiar relations and development of the vomers in *Palaeorhinus* and presented figures showing what he considered a more likely interpretation of the palate. Jaekel's interpretation is certainly more phytosaurian. However, with the present state of the specimen one can only say that it is probably not justifiable to consider the vomers as extending back and forming the anterior border of the 'presphenoidal vacuity.' Concerning the otic capsule little can be said. The opening is present on the right side of the specimen; the left side is restored. This region was restored in *Angistorhinus grandis* from the impression of the inner surface of the bone. A thin film of the bone was still present and showed no indications of such an opening. Indeed, to the writer's knowledge, *Palaeorhinus* is the only form in which the opening has been noted. In conversations with him, Dr. Williston has expressed the opinion that the opening is accidental in this case. One should probably not lay too much stress on its presence in this form till it has been found in other members of this genus. The parieto-squamosal arcade is crushed and largely broken away, giving an appearance to the supratemporal fenestra much like that of *Mystriosuchus planirostrus*. Whether this is the true condition or whether the form is like that of *Angistorhinus* as described above is not certain. The writer is inclined to agree with Lees, however, in assigning to it the form of the latter, but this view should probably also be held as tentative."

The development of the septomaxilla in *P. parvus*, as here described would remove the nasal development as described by Lees from the generic distinctions even if it does not settle the point for *P. bransoni*.

The evidence bearing on the "otic opening" of *P. bransoni* as afforded by *Angistorhinus maximus*, to be described later, is entirely negative. These two genera, the writer believes, are closely related.

It would appear then that the outstanding characteristic of the genus *Paleorhinus* as it is now known, is the anterior position of the nares, about mid-length of the skull. In addition to this, the species of the genus probably share the development of the posttemporal arcade at the deck level with members of the genera *Angistorhinus* and *Promystriosuchus*.¹⁸

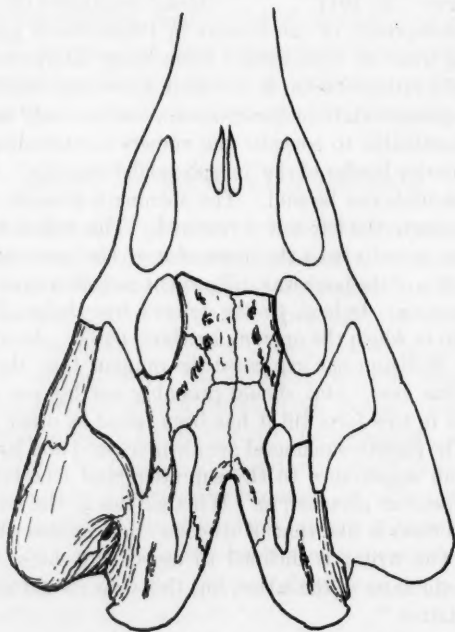


FIG. 3. *ANGISTORHINUS MAXIMUS*; DORSAL VIEW OF POSTERIOR PART OF SKULL

One-sixth natural size

ANGISTORHINUS MAXIMUS, N. SP.

The material on which this species is based consists of the well preserved posterior part of a skull of large size and the posterior end of the left mandibular ramus. The deck of the skull is com-

¹⁸ E. C. Case; Op. cit., 49-60.

plete to the anterior borders of the orbits. The left lateral side is complete from the quadrate to the anterior end of the lateral temporal fenestra. The bar between this opening and the orbit is missing. The right postero-lateral part of the skull is represented by a separate quadrate and other pieces that cannot be definitely articulated.

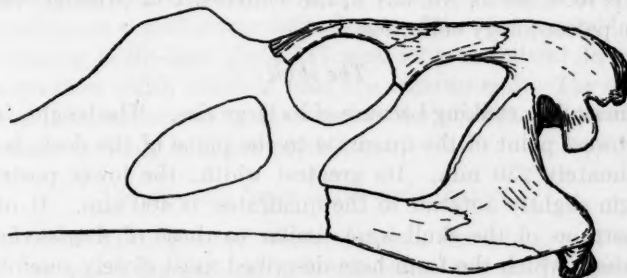


FIG. 4. *ANGISTORHINUS MAXIMUS*; LEFT LATERAL VIEW OF POSTERIOR PART OF SKULL
One-sixth natural size

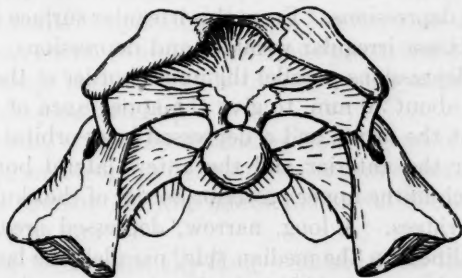


FIG. 5. *ANGISTORHINUS MAXIMUS*; SKETCH RESTORATION OF POSTERIOR SIDE OF SKULL
One-sixth natural size

The upper posterior part of the skull has been laterally compressed and bent upward somewhat. A slight lateral compression of the left side has possibly narrowed the supratemporal fenestra somewhat. The accompanying sketches, figures 3, 4, and 5

are thought to give essentially correct proportions and in this respect are somewhat different from the actual specimen.

These remains were found by the University of Missouri geological field party of the summer of 1927. They came from the top of the Popo Agie beds of the Chugwater Triassic, about 15 miles south of Lander, Fremont County, Wyoming. The specimen is recorded as No. 531 in the University of Missouri vertebrate paleontology collection.

The skull

The skull is striking because of its large size. The height, from the lowest point of the quadrate to the plane of the deck, is approximately 230 mm. Its greatest width, the lower posterior margin slightly anterior to the quadrates, is 400 mm. If other proportions of the skull were similar to those of *Angistorhinus grandis*,¹⁹ which the form here described most closely resembles, its length must have been something over 1,100 mm.

Irregularities of the surface are most evident on the deck of the skull in the region between the orbits, where the lesser features consist of irregularly disposed, low ridges or nodes with small intervening depressions. From this irregular surface is developed a series of larger irregular wrinkles and depressions. A series of the major depressions parallel the upper border of the orbits at a distance of about 30 mm. to give the appearance of pronounced ridges about the orbits and a depressed inter-orbital area. In a like manner the anterior and the antero-lateral borders of the median notch in the upper posterior border of the skull are set off as marked ridges. A long, narrow, depressed area or groove, sharply outlined on the median side, parallels the lateral margin of the deck along the mid-length of each squamosal.

Openings on the dorsal and lateral surfaces

The orbit, judging from the upper and upper-posterior borders, is about 90 mm. in diameter and essentially circular. It is directed outward, a little forward, and very slightly upward. The postorbital bar is very narrow, probably not over 12 mm. wide.

¹⁹ M. G. Mehl; Op. cit.

The *lateral temporal fenestra* is rhomb-shaped with greater and lesser sides measuring roughly 130 mm. and 90 mm. The long diagonal, directed downward and forward at an angle of about 45° with the plane of the lower margin of the skull, is 220 mm.

The *supratemporal fenestra* constitutes one of the most distinctive features of the skull. The boundaries lie in the plane of the dorsal surface without suggestion of a depressed parieto-squamosal arcade such as is characteristic of most of the phytosaur genera. The opening is slit-like, about 117 mm. long and about 18 mm. at its greatest width which is near the anterior end. The opening is rounded anteriorly and pointed at the posterior end with a suggestion of a mid-length constriction.

The separate bones in the dorsal aspect

The *frontal* at its greatest width, between the orbits, is 47 mm. wide. It meets the parietal in a transverse line at the level of the posterior border of the orbits where it has a width of 18 mm. Although the posterior end of the left prefrontal is preserved, the length of the frontal along the median line cannot be determined. It is something over 100 mm.

The *postfrontal* is comparatively large, 55 mm. wide and 80 mm. long. It forms about 40 mm. of the upper posterior border of the orbit and reaches back to within 15 mm. of the anterior border of the supratemporal fenestra.

The *post orbital* is bar-like, extending from the posterior border of the orbit to mid-length of the slit-like supratemporal fenestra. Between this opening and the lateral temporal fenestra the bar has a width of 25 mm.

The *parietal* is exceptionally long. Although its length along the median line of the skull is 90 mm., it forms a considerable part of the border of the deep median notch in the posterior margin of the skull and thus has a total length of about 180 mm. About 90 mm. of the inner border of the supratemporal fenestra is formed by this element.

The *squamosal* is more than ordinarily massive. Its postero-ventral hook is exceptionally long, extending down along the posterior side of the quadrate-squamosal notch a distance of 70

mm. At the posterior side of the squamosal hook is a marked notch similar to that noted in *Pseudopalatus*.²⁰ At the top of the quadrate-squamosal notch a considerable area of the upper end of the quadrate is visible in a lateral view. If the interpretation of the specimen is correct, the squamosal extends downward, along the anterior side of the quadratojugal, in a slender process that forms almost the entire posterior border of the lateral temporal fenestra and all but excludes the quadratojugal from that opening.

The *quadratojugal* is about as high as wide. Its posterior edge is abruptly offset and projects inward to overlap the quadrate. Somewhat above mid-height of this posterior extension the surface is broadly depressed about a large "quadrate" foramen which lies almost entirely in the quadratojugal. The quadrate forms only the lower border of the vertically elongate opening.

The *jugal* is apparently developed as normally. The rugose surface of this bone constitutes the only departure from the generally smooth lateral surface of the part of the skull preserved.

The posterior aspect

The accompanying sketch of the posterior side of the skull seems to be a reasonable interpretation as far as the general proportions and relations are concerned. The height-breadth ratio, about 1:2, is not very different from other genera such as *Mystriosuchus*²¹ and *Machaeroprotopus*.²² The deck of the present form is proportionately narrower, however, than in other forms; a condition that does not appear to be the result of distortion.

Openings of the posterior side

The *posttemporal fenestra* is about 50 mm. long, but it extends laterally as a marked linear depression of the posterior surface about 20 mm. further. The greatest height, near the outer end, is 11 mm.

²⁰ M. G. Mehl; The University of Missouri Studies; 3, no. 1 (1928).

²¹ J. H. McGregor; The phytosauria with especial reference to *Mystriosuchus* and *Rhytidon*; Memoirs Am. Mus. Nat. Hist., 9, pt. 2, 27-101 (1906).

²² M. G. Mehl; New or little known phytosaurs from Arizona; Quart. Bull. Univ. Oklahoma, n.s. 103, 5-28 (1916).

The *quadrate foramen* is 80 mm. above the lower-lateral corner of the quadrate. In a directly posterior view this opening appears as a very small hold that pierces the bone at the lower end of a deep groove in the quadratojugal. In reality the opening is directed downward and very slightly inward and has an antero-posterior extent of 21 mm. and is 12 mm. wide. On the outer surface of the skull the quadrate forms only the posterior end of the opening. On the under side of the bone the opening is almost entirely bordered by the quadratojugal.

Separate bones of the posterior aspect

For the most part, the bones of the posterior side of the skull are not well preserved and leave several points undeterminable.

The *supraoccipital* is extraordinarily large, a condition necessitated by the remarkable posterior extension of the squamosal back of the median notch at the upper-posterior part of the skull. The supraoccipital extends laterally over the posttemporal fenestra to overlap the squamosal for a short distance and terminates at about 120 mm. from the median line. Throughout its extent, its upper margin laps under the parieto-squamosal bar to form the inner wall of the long supratemporal opening. This wall is visible in part through the opening in a superior view. The maximum height of the supraoccipital is probably not at the median line, but at the inner end of the posttemporal opening where it is 55 mm. high.

The *opisthotic* is greatly expanded vertically at its outer end, where it is 50 mm. wide. At mid-length of the posttemporal opening the bone is constricted to 22 mm. It appears to meet the exoccipital at the inner end of the posttemporal opening. The length of the opisthotic thus determined is about 112 mm. Its outer end overlaps the inner side of the squamosal hook and terminates at the conspicuous notch on the posterior side of that process. On its under side the opisthotic firmly clasps the backward and inward-turned upper end of quadrate for a distance of 60 mm., the entire width of the quadrate at its upper end. There is no possibility of a pterygoid process intervening between the opisthotic and quadrate in this form, such as is described by Mehl

in the case of *Machaeroprotopus*.²³ The relation of the "quadrate process" of the pterygoid at its outer end is indicated in the accompanying sketch.

The mandible

The posterior end of the left mandibular ramus was found in proper articulation with the skull. Although some of the suture lines are evident, they are not sufficient to warrant a discussion of the details of construction of the mandible. The striking

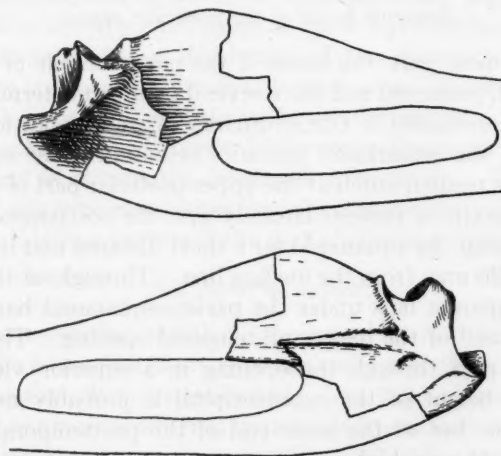


FIG. 6. *ANGISTORHINUS MAXIMUS*; POSTERIOR END OF LEFT RAMUS OF MANDIBLE

A, inner side; B, outer side; figures one-sixth natural size

features, the large size coupled with the delicate construction of the buttresses, are indicated in the accompanying figures, 6a and 6b.

Relationships

The striking features of the species described above are its large size, the development of the posttemporal bar at the level

²³ M. G. Mehl; *op. cit.*, 15-17.

of the deck of the skull, and the remarkable posterior extent of the squamosals to form a deep median notch.

Two genera, *Angistorhinus* and *Promystriosuchus*,²⁴ have as their outstanding characteristic, an elevated posttemporal bar. To these genera should be added *Paleorhinus* in that it probably has the same posttemporal development. Case distinguishes between *Angistorhinus* and *Promystriosuchus* as follows:²⁵

" . . . The two forms differ in that in *Angistorhinus* the squamosals are much larger and extend well beyond the occipital condyle, so that it is not visible from above; there is a much sharper depression of the rostrum anterior to the external nares; the anterior end of the rostrum is much more down-turned and is wider; the pterygoid is represented by Mehl as having no external process and the transverse joins it laterally, not by underlying an external process; the posterior arm of the parietal is short, the greater part of the upper edge of the posterior part of the skull being formed by the squamosals; the opisthotic process extends out to the squamosal, but is surrounded by it both above and externally; the post-temporal foramen is relatively large."

It is evident that many of the differences pointed out by Case serve equally well to distinguish between the species here described and *Promystriosuchus*.

The outstanding difference between *Paleorhinus* and *Angistorhinus*, as these genera are now known, is the mid-length position of the external nares in the former. Although it is impossible to determine the position of the nares in *A. maximus*, it seems unlikely that this form should duplicate so many features of the posterior part of the skull of *A. grandis* as it does and depart radically in the relative position of the nares. Like *A. grandis*, the present species has a marked extension of the squamosals posterior to the occipital condyle and a posterior extension of the parietals at the median line so as to conceal the supra-occipital in a superior view.

A. maximus is readily distinguished from *A. grandis* through

²⁴ E. C. Case; A new Parasuchian, *Promystriosuchus ehlersi*; Carnegie Inst. Washington, Publication No. 321, 49-60 (1922).

²⁵ Ibid., 57.

the conspicuously narrow and much longer supratemporal fenestrae and the greater posterior extent of the squamosals in the former, as well as differences in many minor details such as the laterally directed orbits, the exceptionally large supraoccipital, and the long and narrow posttemporal openings.

Angistorhinus? sp.

Numerous isolated bones and fragments, some of which are indeterminate beyond the fact that they are parts of a phytosaur of large size, form a small part of the Wyoming collection. Four of these, however; an interclavicle, an ilium, a femur, and a scapula, show characters that are distinctive. These bones are not associated and almost certainly are from four different individuals.



FIG. 7. *ANGISTORHINUS? SP.*; LEFT SCAPULA OF A LARGE PHYTOSAUR
One-third natural size

A large *interclavicle* No. 532, University of Missouri vertebrate paleontology collections, was found in the same horizon and not far distant from the skull of *Angistorhinus maximus* described above. Only the anterior part, about one-third the total length, is preserved, but this shows the bone to be of exceptional massiveness. Some of the outstanding characters of this form are evident in a comparison with those of *Mystriosuchus planirostris*.²⁶

²⁶ J. H. McGregor; op. cit.

In the form here described the median anterior ridge that separates the clavicles is relatively longer and the clavicular facets or grooves extend out and back at a markedly obtuse angle with the median line rather than at right angles as is the case in *M. planirostris*. At the union of the interclavicular and the subclavicular ridges the surface of the bone is produced into a broadly rounded boss. There is no pitting on the surface of the bone.



FIG. 8. *ANGISTORHINUS?* SP.; ANTERO-VENTRAL VIEW OF RIGHT FEMUR OF A LARGE PHYTOSAUR

The restriction or neck of the interclavicle is not as great and is less sharp than in the form figured by McGregor, and is located much further anteriorly in the present form.

The greatest width of the form here described, just back of the clavicular facets, is 135 mm. The width of the postclavicular constriction is about 88 mm. The distance of this constriction from the clavicular facets is about 125 mm.

A complete *ilium* of large size with the fused proximal end of the pubis, No. 535, University of Missouri vertebrate paleontology

collections, may add to the knowledge concerning *Angistorhinus*. The specimen was found in the Popo Agie beds of the Chugwater formation north of Bull Lake Creek, Fremont County, Wyoming. This ilium is larger than any other that has come to the attention of the writer. Because of the large size, commensurate with that of *A. maximus* described above and the fact that this is the only large phytosaur that is known from Wyoming, it is logical to assume that the ilium belongs to that form. It should be emphasized, however, that the lack of definite association of ilium and skull leaves the relationship implied and not proven.

In general proportions the ilium is much like that of *Paleorhinus parvus* as described above, although they differ somewhat in outline, particularly the outline of the upper margin. The supra-acetabular ridge of the former has a greater antero-posterior extent and is less sharp and flange-like than in the form here described. The acetabulum of *P. parvus* is apparently the shallower of the two.

In the form here described the sacral scar is roughly oval in shape with axes of about 100 mm. and 40 mm. The long axis is in a line between the upper anterior and the lower posterior points of the ilium. At its lower end the scar approaches to within 45 mm. of the lower border of the ilium.

The union with the pubis is evident but the two bones are closely fused. The development of the part of the pubis that is preserved is almost identical with that of *P. parvus* and it seems likely that it had a similar outward-bending lower, anterior margin.

A single *scapula*, with the upper end missing, is unlike others that have been described. The articular end is very massive and has an exceptionally large coracoid facet. This facet is sharply set off from the glenoid facet which is conspicuously high. The glenoid facet is about as high as wide and extends up from the coracoid facet almost at right angles. The upper end of the scapula appears to be much more recurved than is ordinarily the case. This bone is No. 534 B.P., University of Missouri. It came from Bull Lake Creek, Fremont County, Wyoming.

A *femur* of distinctive characters differs markedly from that of *Paleorhinus parvus*. The distal end of the bone, about 80 mm.,

is missing. The total length of the femur was probably about 400 mm. The proximal end, although expanded, is only 73 mm. wide and is not produced anteriorly as in *paleorhinus*. The proximal articulation is essentially flat instead of broadly rounded as in most phytosaur genera. It is possible, but not at all likely, that the articulation in this specimen was cartilaginous.

The shaft of the bone is flattened-oval in cross-section, with sharp anterior and posterior edges throughout most of its length. This seems to be a normal character and not the result of crushing. Near the proximal end of the shaft on its lower anterior side is a broad, rounded ridge or trochanter. This swelling starts at about 60 mm. below the proximal end of the bone and is 90 mm. long. At mid-length it is 24 mm. wide (fig. 8).

The specimen is No. 533 in the University of Missouri vertebrate paleontology collections. It came from Bull Lake Creek, Fremont County, Wyoming.

These separate bones described under "*Angistorhinus?* sp." might well belong to *A. maximus*, so far as size is concerned and as such would add valuable distinguishing features to the species and genus. However, there is no direct evidence of such a relationship, and there is no assurance that the bones do not belong to an entirely different genus.

Generic characteristics of Angistorhinus

The genus *Angistorhinus* is known to date from three skulls representing three different species. Other remains such as the isolated bones described above under *Angistorhinus?* sp. are of no value in generic diagnosis and stratigraphic significance. There are numerous characters that vary in the different species, such as the direction of the plane of the orbit and depth of the posterior median notch. Doubtless some of the minor characters will be shown to be shared by all species of the genus. At present the outstanding features that can be considered as diagnostic of the genus are few. Among these may be listed safely: posttemporal bar at level of skull deck; supraoccipital concealed in a superior view; marked posterior extension of squamosals;

anterior border of external nares and antorbital fenestrae about even; and simply arched narial vault.

Wyoming phytosaur localities

The Wyoming localities in which phytosaur remains of importance have been collected are few, but there are numerous localities in the state from which fragments recognizable as phytosaurian have come. To the writer's knowledge there are nine such localities in west-central Wyoming, any one of which may, with thorough investigation, produce remains of value. The following list, although undoubtedly not complete, will serve to show the general distribution and nature of the Wyoming phytosaur remains. It should be emphasized here that the bone bearing horizons in these localities may not be time equivalents although they are all in the Popo Agie, Chugwater, beds. As pointed out by Branson and Mehl,²⁷ the conditions recorded in the Popo Agie beds represent near-shore or actual land conditions that undoubtedly existed within limited areas, first one place and then another, from time to time throughout the Chugwater times and are not evidence of contemporaneity (fig. 9).

1. Little Popo Agie River, Fremont County.
Angistorhinus maximus; skull and mandible, No. 531, University of Missouri.
Angistorhinus? sp.; interclavicle, No. 532, University of Missouri.
2. Willow Creek, Fremont County.
Phytosaur vertebrae, fragmentary, unidentified.
3. Squaw Creek, Fremont County.
Paleorhinus bransoni; skull and mandible, University of Chicago.
4. Between Squaw and Baldwin Creeks, Fremont County.
Angistorhinus grandis; skull and mandible, University of Chicago.
5. Baldwin Creek, Fremont County.
Angistorhinus gracilis; skull and mandible and associated skeletal parts (skeleton undescribed, inclosed in an extremely hard matrix), University of Chicago.
6. Sage Creek, Fremont County.
Paleorhinus parvus; skull and mandible, and associated skeletal parts, No. 530, University of Missouri.

²⁷ E. B. Branson and M. G. Mehl; Triassic vertebrate fossils from Wyoming; Science 67, 325-326 (1928).

7. Bull Lake Creek, Fremont County.

Angistorhinus; sp.; dissociated parts; femur, ilium, and ischium; Nos. 535, 534, and 533, University of Missouri. This generic reference is at present without sufficient foundation for use in stratigraphic work.

8. "Black Mountain" branch of Dry Creek, Fremont County.

Isolated phytosaur vertebrae.

9. Red Creek, Hot Springs County.

Isolated fragmental phytosaur vertebrae.

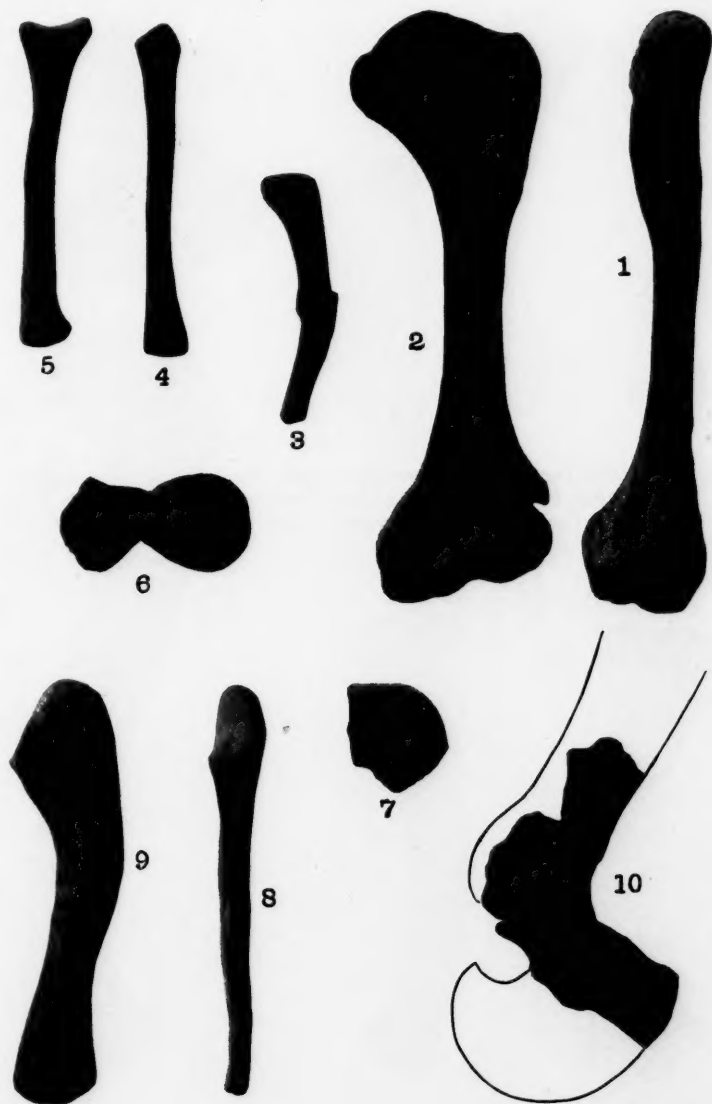
SUMMARY OF CONCLUSIONS

Two genera of Phytosauria, *Paleorhinus* and *Angistorhinus*, are known from the Triassic of Wyoming, and are probably not represented elsewhere. Of the genus *Paleorhinus* two specimens representing two species are known, *P. bransoni*, the type of the genus, and *P. parvus*. The two specimens came from localities some distance apart and are of little stratigraphic value. The genus *Angistorhinus* is represented by three specimens each of a different species, *A. grandis*, *A. gracilis*, and *A. maximus*. The first two of these specimens came from localities separated by a few miles with intervening exposures of such a nature that one may safely assume the horizons are essentially the same. The third specimen came from a locality at a distance such that one cannot be certain of the correlation of the horizon except in a general way.

PLATE XXXVII

PALEORHINUS PARVUS

Figs. 1 and 2, left humerus, anterior and inferior views; fig. 3, right radius? a section showing healed fracture; figs. 4 and 5, left radius from posterior and inner sides; fig. 6, dermal scutes showing irregular outline and overlapping; fig. 7, mesopodial, presumably left tibia; figs. 8 and 9, anterior and outer sides of left ulna; fig. 10, left caracoid and scapula. All figures about one-third natural size.



M. G. MEHL

PHYTOSAURIA OF WYOMING TRIASSIC

PLATE XXXVIII

PALEORHINUS PARVUS

Fig. 1, left femur, inferior view; figs. 2 and 3, anterior and posterior views of left tibia; figs. 4 and 5, anterior and posterior views of left fibula; figs. 6 and 7, antero-lateral and postero-lateral views of right pubis. All figures about one-third natural size.

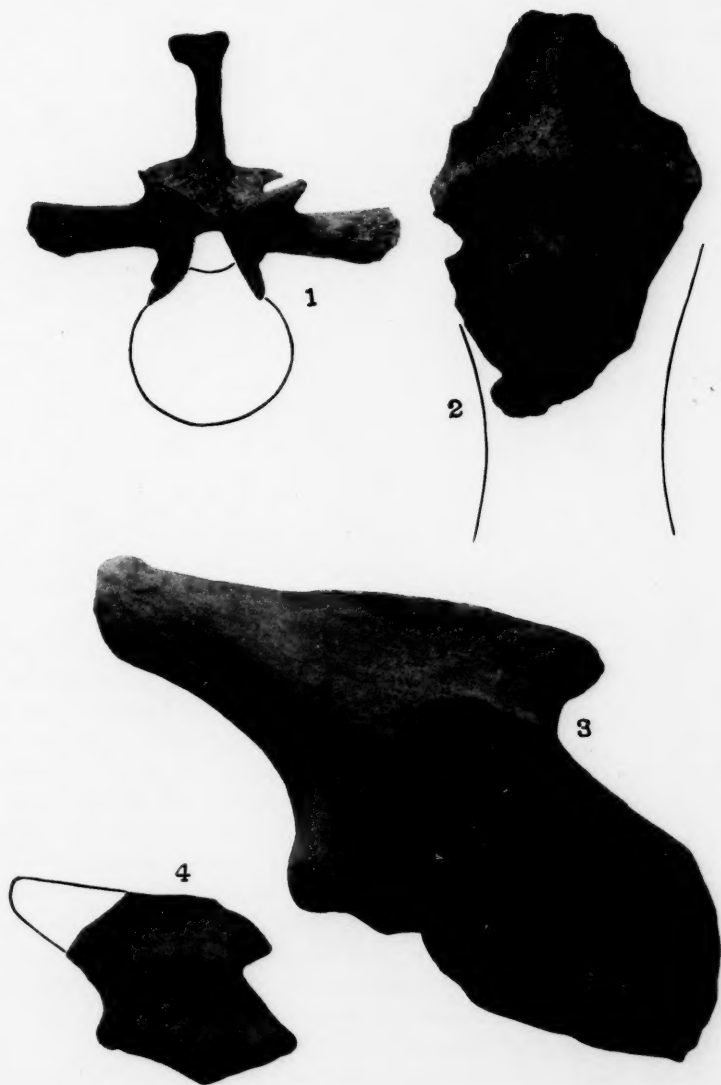


M. G. MEHL

PHYTOSAURIA OF WYOMING TRIASSIC

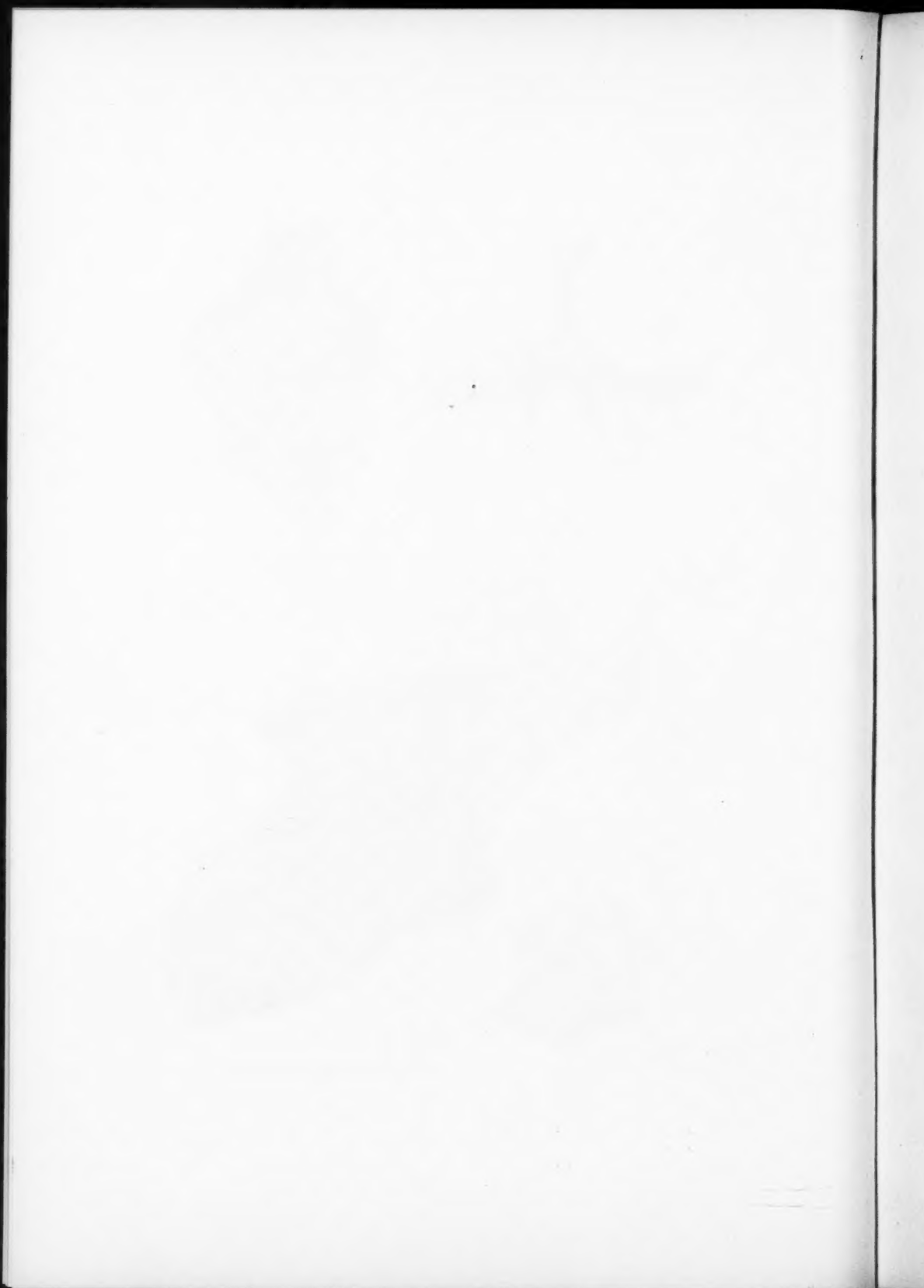
PLATE XXXIX

Fig. 1. *Paleorhinus parvus*; anterior view of thoracic vertebral arch. Fig. 2. *Angistorhinus?* sp.; ventral view of a large interclavicle. Fig. 3. *Angistorhinus?* sp.; right ilium and co-joined proximal end of pubis of a large phytosaur. Fig. 4. *Paleorhinus parvus*; right ilium. All figures one-third natural size.



M. G. MEHL

PHYTOSAURIA OF WYOMING TRIASSIC



A RESTUDY OF SOME OF THE ORDOVICIAN AND SILURIAN CEPHALOPODS DESCRIBED BY HALL

AUG. F. FOERSTE

Received May 5, 1928; published August 9, 1928

The present paper is a study of a considerable number of the Ordovician and Silurian cephalopods described by Hall in the first two volumes of the "Paleontology of New York" in 1847 and 1852, and of those Ordovician cephalopods which he described in his "Report of the Superintendent of the Geological Survey of Wisconsin" in 1861. Many years have passed since these publications appeared. In the mean time new species were discovered which could have been discriminated more readily from the species described by Hall if the latter had been described more fully, and new generic terms were proposed, some of which were applicable to the Hall species. Moreover, a more intensive study of the Hall types indicated that in several cases more than one species had been included under the same specific name. Under these circumstances a restudy of these types was undertaken in order to learn what additional information they offered, and in what respect they were deficient.

Some of the generic affiliations here proposed must be regarded as tentative, since the types of some of the species present no exact knowledge of the structure of the siphuncle. In the case of the three species here retained under *Orthoceras*, since this name is used at present for almost any smooth orthoconic cephalopod which is not distinctly actinoceroid. However, if the terms *Manitoulinoceras* and *Rizoceras* are to be applied with any exactness, a knowledge of the structure of the siphuncle of conchs is to be referred to these genera becomes essential. The situation is even worse in the case of Hall's *Oncoceras gibbosum*, which certainly is not a *Gomphoceras*, but which is not a suitable type of a new genus in the absence of all knowledge of the structure of its

siphuncle. Notwithstanding these deficiencies it is hoped that the contribution here offered may find some use. As frequently heretofore, the writer is greatly indebted to Dr. Chester A. Reeds of the American Museum of Natural History for the very liberal way in which he has loaned the treasures of this museum for study.

LIST OF SPECIES HERE STUDIED

Ordovician

1. *Ephippiorthoceras subarcuatum* (D'Orbigny)
2. *Cycloceras undulostriatum* (Hall)
3. *Spyroceras anellus* (Conrad)
4. *Spyroceras middlevillense* Foerste
5. *Spyroceras olorus* (Hall)
6. *Spyroceras bilineatum* (Hall)
7. *Spyroceras textile* (Hall)
8. *Spyroceras clathratum* (Hall)
9. *Cyrtorizoceras constrictostriatum* (Hall)
10. *Cyrtorizoceras filosum* (Conrad)
11. *Cyrtorizoceras camurum* (Hall)
12. *Cyrtorizoceras whitneyi* (Hall)
13. *Cyrtorizoceras multicameratum* (Hall)
14. *Cyrtorizoceras* sp. (Carlisle, Pa.)
15. *Zitteloceras hallianum* (D'Orbigny)
16. *Zitteloceras beloitense* Foerste
17. *Zitteloceras percurvatum* Foerste
18. *Zitteloceras* (?) *tenuistriatum* (Hall)
19. *Centrocyrtoceras subannulatum* (D'Orbigny)
20. *Manitoulinoceras neleum* (Hall)
21. *Manitoulinoceras middlevillense* Foerste
22. *Oncoceras abruptum* Hall
23. *Deiropoceras distans* (Hall)
24. *Conradoceras macrostomum* (Hall)
25. *Diestoceras alceum* (Hall)
26. *Ulrichoceras beloitense* Foerste

Silurian

27. *Orthoceras multiseptum* Hall
28. *Orthoceras virgulatum* Hall
29. *Orthoceras clavatum* Hall
30. *Kionoceras subcancellatum* (Hall)
31. *Kionoceras lockportense* Foerste
32. *Dawsonoceras* sp. (Wolcott, New York)
33. *Rizoceras lockportense* Foerste
34. *Lechritrochoceras notum* (Hall)
35. *Armenoceras vertebratum* (Hall)
36. *Amphicyrtoceras abruptum* (Hall)

37. *Amphicyrtoceras* sp. (Niagara Falls—1)
38. *Amphicyrtoceras* sp. (Lockport)
39. *Amphicyrtoceras subcancellatum* (Hall)
40. *Amphicyrtoceras* sp. (Niagara Falls—2)
41. *Gomphoceras* (?) *gibbosum* (Hall)

1. *Ephippiorthoceras subarcuatum* (D'Orbigny)

Plate XLIV, figs. 3A, B

Cyrtoceras arcuatum Hall, Pal. New York, 1, 196, pl. 42, figs. 5 a, b, c (1847).

Cyrtoceras subarcuatum D'Orbigny, Prodr. de Pal., 1, 2 (1849).

The specimen consists of fragments of two conchs, and was figured in an inverted position by Hall. The larger specimen, evidently to be regarded as the type, consists of a living chamber to which 8 camerae are attached; of these, the lower 4 camerae occupy a combined length of 8 mm., while the upper 4 have a combined length of 5.5 mm., suggesting that the conch had reached maturity. The length of the living chamber apparently was at least 19 mm. Into the living chamber of this larger specimen, the larger end of a smaller specimen was inserted by current action in an inverted position. Both conchs are straight or deviate only slightly from a straight course, both are strongly compressed laterally, and their other features are such that both may be regarded as belonging to the same species.

The larger specimen has a dorso-ventral diameter of 14 mm. at its base and of 16 mm. at a distance of 25 mm. farther up; the corresponding lateral diameters are at least 8 and 8.5 mm., but the shell may have been somewhat compressed laterally. The smaller specimen enlarges its dorso-ventral diameter 3 mm. in a length of 25 mm. The lateral sides tend to be flattened, the dorsal and ventral sides being more strongly curved transversely.

The sutures of the septa form very shallow lateral lobes, and distinct dorsal and ventral saddles. The septa curve dorso-ventrally with a radius of 10 mm., but their lateral curvature is small. The siphuncle apparently is indicated indistinctly, and is almost in contact with one of the more narrowly rounded sides of

the specimen, here regarded as the ventral one. It will require a better specimen to determine this point definitely.

Locality and Horizon.—From Middleville, New York, in the lower part of the Trenton formation.

No. 819, American Museum of Natural History.

2. *Cycloceras undulostriatum* (Hall)

Plate XL, figs. 1 A-D

Orthoceras undulostriatum Hall, Pal. New York, 1, 202, pl. 43, figs. 7 a-k, (1847).

Largest Figured specimen.—The specimen represented by figures 7a and 7b on plate 43, cited above, enlarges from a diameter of 14.5 mm. at the base to 16 mm. at the top, the length of the specimen being 51 mm. The apical angle is 3 degrees. At the top of the specimen the cross-section is circular; at its base the conch is strongly depressed. Five annulations occur in a length equal to the diameter of the conch. Along one half of the circumference of the specimen these annulations are almost directly transverse; along the other half they curve downward a distance equal to the space between two consecutive annulations. The annulations are about two-thirds of a millimeter in height, and are much narrower than the intervening grooves. Along the crest of one of the annulations there are traces of transverse raised lines, as in typical *Cycloceras*.

Second Figured Specimen.—The specimen represented by figures 7d, 7f, and 7h on plate 43, cited above, enlarges from 13.5 to 14 mm. in a length of 31 mm., the entire length of the specimen being 39 mm.; hence the apical angle must be extremely small. In its present condition the specimen is strongly depressed dorso-ventrally, its diameter in that direction being 9 mm.; evidently this depression is due to pressure during fossilization. Five annulations occur in a length equal to the diameter of the conch. These annulations are nearly directly transverse along one side of the specimen and along the median part of the opposite side, but they rise laterally at an angle changing from 70 to 55 degrees on passing from the first toward the second side. Six

camerae occur in the same length as the crests of 9 annulations. The sutures of the septa are directly transverse. The septa are rather strongly concave. In addition to the annulations there are transverse raised lines, parallel to the annulations. Seven of these striae occur in a length of 1 mm.

Third Figured Specimen.—The specimen represented by figure 7e on the plate 43, cited above, is 28 mm. long, and 11 mm. in diameter, showing no perceptible increase in diameter in this length. The specimen is compressed laterally, the narrower diameter being 9.5 mm. Five annulations occur in a length equal to the diameter of the conch. These annulations slant downward from one side to the other at an angle of about 75 degrees. The number of annulations and of camerae agree within the length of the specimen. There are traces of transverse striae, but these are far less clearly defined than those on the preceding specimen.

Fourth Figured Specimen.—The specimen represented by figures 7i and 7k on plate 43, cited above, is 21 mm. long, and enlarges from 11.5 mm. at the base to 12.5 mm. in a length of 14 mm. Along a considerable part of the circumference of the specimen the annulations are directly transverse, but along a relatively short width they rise rather strongly and abruptly. Six annulations occur in a length equal to the width of the specimen. Six transverse striae occur in a length of 1 mm.

Locality and Formation.—Middleville, New York, in the Trenton limestone.

Specimens numbered 804, in the American Museum of Natural History.

Remarks.—While all of the specimens belonging to the type series agree in having flexures or strong downward slants in a greater or smaller part of the entire course of the annulations, the exact location of the siphuncle is not known in these specimens, so that the orientation of the flexures and slants of these annulations can not be determined with confidence.

3. *Spyroceras anellus* (Conrad)

Plate XL, fig. 4

Orthoceras anellus Conrad, Proc. Acad. Nat. Sci. Philadelphia, 1, 334 (1843).

Orthoceras anellus Hall, Pal. New York, 1, 202, pl. 43, figs. 6 a-c (not figs. 6 d-f) (1847).

Specimen 39 mm. in length, enlarging from a diameter of 10 mm. at the base to 12 mm. at the top, indicating an apical angle of 3.5 degrees. Specimen circular in cross-section at the larger end, slightly depressed at the smaller end. Sixteen annulations occur in a length of 37 mm., or 5.5 annulations in a length equal to the diameter of the conch. Along the entire length of the specimen the sutures of the septa lie in the lowest part of the grooves between the annulations on the ventral side of the conch. The annulations slope slightly downward from the ventral toward the dorsal side of the conch, especially along the upper part of the specimen, where they form an angle of about 3 degrees with the horizontal. In consequence, the annulations here are about on an elevation with the sutures of the septa on the dorsal side of the conch. The annulations are remarkably sharp and narrow, considering the small size of the specimen; the crests rise fully 1 mm. above the intervening grooves at the top of the specimen. These crests are very narrowly rounded. The surface of the shell is ornamented by numerous minute filiform vertical raised lines, of which usually 9 occur in a width of 1 mm.; occasionally 8 occur in this width, or even only 7. At this rate 250 vertical lines should occur within the circumference of the conch.

At the top of the specimen the concavity of the septa is about 2.5 mm. The sutures of the septa are almost directly transverse. The passage of the siphuncle through the septum is about 1.2 mm. in diameter, and its center is located about 4.8 mm. from the ventral wall of the conch where the dorso-ventral diameter is 11.8 mm.

Locality and Formation.—Mineral Point, Wisconsin, Beloit member of the Black River formation.

Specimen 805-3, American Museum of Natural History.

4. *Spyroceras middlevillense* Sp. nov.

Plate XL, figs. 3 A, B

Orthoceras anellus Hall, Pal. New York, 1, 202, pl. 43, figs. 6d-f (not figs. 6 a-c) (1847).

Specimen 30 mm. in length. At one end there is a horizontal cross-section 7 mm. in diameter, indicating a circumference of about 22 mm. At the opposite end the cross-section is very oblique but apparently of about the same diameter. Evidently the apical angle is small. The crests of 9 annulations occur in a length of 16 mm., or 4.5 annulations in a length equal to the diameter of the conch. Considering the small size of the conch, the annulations are strongly defined, and narrower than the intervening grooves. Five sharply defined but very narrow raised vertical lines occur in a width of 1 mm.; at this rate about 90 vertical lines should occur within the circumference of the conch. These lines have about one-fourth of the width of the spaces between them, which are relatively flat. The horizontal striae are so fine and faint as to be recognized only with difficulty, even under a good lens.

Locality and Formation.—Middleville, New York, in the Trenton limestone.

Specimen 805-1, American Museum of Natural History.

Remarks.—Compared with typical *Orthoceras anellus* from Mineral Point, Wisconsin, the annulations are equally strong, but the vertical filiform lines are distinctly less numerous and more distant from each other.

Possibly this specimen is only the young of *Spyroceras bilineatum*, but its apical angle appears smaller, and the annulations appear stronger. Moreover, there is no distinct alternation in size of the vertical raised lines.

5. *Spyroceras olorus* (Hall)

Plate XL, fig. 9

Orthoceras vertebrale Hall (not Schlotheim), Pal. New York, 1, 201, pl. 43, figs. 5a-c (1847).

Orthoceras olorus Hall, in Miller's American Pal. Foss., 245, (1877).

Type.—Specimen about 100 mm. in length, enlarging from a diameter of 26 mm. at the base to 27 mm. at the top; apical angle very small. Specimen strongly depressed by pressure, dorso-ventral diameter 20 mm. in its present condition. Sixteen annu-

lations occur in a length of 84 mm., or 6 annulations in a length equal to the diameter of the conch at the base of the specimen, and 5.5 annulations in a corresponding length at its top. The annulations are about two-thirds of a millimeter in height, and are distinctly narrower than the intervening broad horizontal grooves. There are about 9 or 10 vertical raised lines in a width of 10 mm., and it is estimated that about 60 of these vertical striae occurred within the circumference of the conch, judging from the number counted on one side of the specimen. The spaces between these vertical lines are relatively flat, and are striated transversely by very faint and very fine lines, not readily seen even under a lens.

Locality and Formation.—Middleville, New York, in the Trenton limestone.

Specimen 803, American Museum of Natural History.

Remarks.—In its small apical angle, and in the absence of distinct alternation in the size of the vertical raised lines *Orthoceras olorus* is resembled by *Orthoceras middlevillense*, but the annulations of the latter form are sharper, and the vertical raised lines also appear sharper and narrower, although the latter may be due simply to the smaller size of the specimen serving as a type of *Orthoceras middlevillense*.

6. *Spyroceras bilineatum* (Hall)

Plate XL, figs. 5 A, B; 7

Orthoceras bilineatum Hall, Pal. New York, 1, 199, pl. 43, figs. 2b, d (1847).

Specimen 25 mm. in length, obliquely broken off at top and bottom. Apical angle about 5 degrees, but the specimen is too short for accurate measurement. Diameter at upper end of specimen 16 mm. Five annulations occur in a length equal to the diameter of the conch. These annulations are about two-thirds of a millimeter in height, they are rather broadly rounded, and they are separated by intermediate grooves of about the same width or slightly wider. The surface of the conch is ornamented by about 90 vertical striae, of which 45 are distinctly broader and more

prominent, while the intermediate striae are narrower. Both sets of striae are much narrower than the spaces between them, equalling from one-third to one-fourth of the latter. Under a lens very faint but numerous transverse lines are seen, about 10 or 11 in a length of 1 mm. These transverse striae are too faint to be visible except on specimens with exceptionally well preserved surfaces.

Locality and Formation.—Middleville, New York, in the Trenton limestone.

Specimen 808-1, American Museum of Natural History. Original of figs. 2b, d on plate 43 cited above.

The originals of figures 2a and 2c on plate 43 are missing.

Variety α of Hall.—The specimen represented by figures 3a, b, c, on plate 43 is 50 mm. in length, but is badly crushed, and its lower part is distorted in addition in such a manner as to crowd the transverse annulations and sutures of septa into oblique positions. In all respects this so-called variety is similar to the specimen here selected as the type; in the character and number of the annulations, and in the character and number of the vertical striae. The number of the latter around the entire circumference of the conch can not be determined exactly but is estimated at about 70 in case of the more prominent striae. Between almost all of these there are intermediate, less prominent, vertical striae. The greater number of more prominent vertical striae is accounted for by the greater diameter of this specimen, which in its present condition is about 20 mm. near mid-length. From Middleville, New York.

The original of figure 6d-f on plate 43, described under *Orthoceras anellus* by Hall, may belong here. It is not identical with the type of that species, originally described from Mineral Point, Wisconsin. For the present it is regarded as distinct from *Orthoceras bilineatum*, since it presents no trace of alternation in size of the vertical striae, appears to have a much smaller apical angle, and has more strongly defined annulations. Moreover, the number of vertical raised lines is large, compared with the diameter of the specimen.

7. *Spyroceras textile* (Hall)

Orthoceras textile Hall, Pal. New York, 1, 199, pl. 43, figs. 1a, b (1847).

The type of the specimen has been lost so that no information can be secured beyond that furnished by the original description and the accompanying figures. The conch enlarged slowly, four annulations occur in a length equal to the diameter of the conch, when counted from crest to crest. These annulations are conspicuous. The sutures of the septa occur in the grooves between the annulations, and therefore about equal the latter in number. Septa rather deeply concave. Siphuncle not exposed. The surface of the shell was marked by "fine longitudinal and transverse striae, which are closely arranged, the series being equidistant from each other, giving the surface the appearance of a woven texture."

Watertown, New York, in the lower concretionary beds of the Trenton limestone.

Remarks.—A similar species was described as *Spyroceras microcancellatum* Foerste from the Ellis Bay formation at Junction Cliff, in Anticosti.

8. *Spyroceras clathratum* (Hall)

Plate XL, figs. 6 A, B

Orthoceras clathratum Hall, Pal. New York, 1, 201, pl. 43, figs. 4a-c (1847).

Specimen 17 mm. in length, enlarging from 5.6 mm. in diameter at the base to about 6.6 mm. at a point 9 mm. farther up, indicating an apical angle of about 6.5 degrees. Specimen curved lengthwise, apparently chiefly owing to distortion, though there may have been a small amount of lengthwise curvature originally before fossilization. Eight annulations occur in a length of 13 mm., or from 4.5 to 5 annulations in a length equal to the diameter of the conch. The annulations are fairly prominent, but not sharply elevated as in *Orthoceras anellus*. At mid-length of the specimen they slope downward from the ventral toward the dorsal side of the conch at a small angle with the horizontal. The

only septum indicated occurs here in the groove between the annulations.

The surface of the shell is ornamented by about 40 sharply defined vertical raised lines, which might almost be called ribs, considering the small size of the conch. The grooves intervening between these vertical ribs are 4 or 5 times as wide as the ribs and concave in curvature. In addition the entire surface, including both the annulations and the intermediate horizontal grooves, is ornamented by transverse, nearly equidistant lines, of which about 7 occur in a length of 1 mm. along the upper part of the specimen, while about 9 occur in this length along its lower part. These transverse lines are specially distinct in the vertical grooves between the vertical ribs, and they are distinctly narrower than the intervening horizontal grooves, especially along the upper part of the specimen.

Locality and Formation.—Middleville, New York, in the Trenton limestone.

Specimen 806, in the American Museum of Natural History.

9. *Cyrtorizoceras constrictostriatum* (Hall)

Plate XLII, figs. 1 A, B, C; 2 A, B

Cyrtoceras constrictostriatum Hall, Pal. New York, 1, 195, pl. 42, figs. 3 c, d; 2 a, b (1847).

Two specimens were figured by Hall; of these, that specimen which is represented by his figures 3 c, and 3 d is to be regarded as the type, since it is on this specimen that the name *constrictostriatum* is founded. Along 3 vertical lines on the left side of the specimen the transverse striae curve distinctly downward. Two of these vertical lines are about 7 mm. apart and are located about equal distances from the median part of the ventral side; the third vertical line is 4 mm. distant from the nearest one of the first two, and is located on the left dorso-lateral side of the specimen. On the right half of the dorsal side there is no downward flexure of the transverse striae along any line corresponding to the third one of the vertical lines on the left side, just described; on the middle part of this right side the shell is not preserved. However, there

is no reason to believe that this downward flexure of the transverse striae along definite vertical lines is a feature characteristic of the species, although it serves to indicate which one of the two specimens figured by Hall should be selected as the type.

The specimen apparently consists of the living chamber with 3 camerae still attached; however, only the two lower ones of these three camerae are distinctly outlined by sutures, the suture at the base of the living chamber being obscured by the shell itself. The shell may be traced distinctly on the right side of the specimen up to a height of 22 mm. above the supposed base of the living chamber, and obscurely for a distance of 4 mm. additional. The conch is compressed laterally. At the base of the specimen the dorso-ventral diameter is 20 mm., and the lateral diameter is 18 mm.; at a point 17 mm. farther up the dorso-ventral diameter is 24 mm. The living chamber apparently widens until a distance of 15 mm. above its base is reached. Above this point it may narrow laterally, but this narrowing is indicated in an unsatisfactory manner. The conch is curved lengthwise in a dorso-ventral plane, the ventral side being convex and the dorsal side concave. The radius of curvature of the ventral side is about 50 mm., and that of the dorsal side is about 100 mm., the concave curvature here being slight. The vertical outline of the shell apparently is falcate, with a moderate lengthwise curvature, but not enough of the length of the shell remains to determine this, especially in view of the small part of the phragmacone present.

The 3 camerae occupy a combined length of 9 mm. at a point where the dorso-ventral diameter of the conch at the top of the series of camerae being counted is 21 mm. According to these measurements the number of camerae in a length equal to the dorso-ventral diameter should be about 7 or 8, if counted along their ventral side. The sutures of the septa are only slightly concave along the lateral sides of the specimen. Their most striking feature is that they rise slightly more than 1 mm. higher on the dorsal than on the ventral side, which is an unusual feature among Cyrtoceroidea.

The transverse striae are very numerous and are associated with transverse wrinkles having the same direction. Of these

wrinkles there are 6 to 8 in a length of 5 mm., the number of striae in the same length being 23. Along the dorsal side of the conch the striae are directly transverse and they continue in this direction as far as the middle of the lateral sides, beyond which they curve increasingly downward to the middle of the ventral side where former stages of the hyponomic sinus show a depth of nearly 1.5 mm. Owing to the downward slope of the sutures from the dorsal toward the ventral side, the transverse striae rise more than 1 mm. above the sutures on being traced from the dorsal side to the middle of the lateral sides.

The second specimen figured by Hall (his figures 2a and 2b) does not preserve any part of the shell, but it has a similar small lengthwise curvature, a similar ratio between the dorso-ventral and the lateral diameters, a similar ratio between the number of camerae and the dorso-ventral diameter of the conch, and a similar short living chamber. The living chamber and 9 camerae are present. The uppermost camera is about 1 mm. in length, and indicates by its shortness that the specimen was mature. The other 8 camerae equal in length the dorso-ventral diameter of the conch at the base of the living chamber. The cast of the interior of the living chamber contracts slightly about 12 or 13 mm. above the base of the chamber, and the aperture probably was about 4 or 5 mm. farther up, so that the entire length of the living chamber probably did not exceed 16 or 17 mm., which is relatively short. The upper part of the phragmacone had a radius of curvature of 50 or 60 mm. along its ventral side, and of 70 or 80 mm. along its dorsal side, but the living chamber is practically straight. At the base of the living chamber the dorso-ventral diameter is 22 mm., and the lateral one is 18.5 mm. Here the sutures of the septa are nearly straight and they rise slightly from the dorsal toward the ventral side of the conch; but at the base of the specimen the sutures slant downward moderately in this direction, the greatest concavity of the septum being slightly dorsad of the center.

Locality and Horizon.—From Middleville, New York, in the lower part of the Trenton formation.

No. 818. American Museum of Natural History.

Remarks.—*Cyrtoceras constrictostriatum* is distinctly broader and less curved lengthwise than *Cyrtoceras filosum* or *Cyrtoceras camurum*. Apparently its relationship is with those Cyrtoceroids which occur in the Platteville member of the Black River formation in the Upper Mississippi Valley, and which are laterally compressed, moderately curved lengthwise, and have relatively short living chambers, not distinctly contracted toward the aperture, excepting along the shallow annular groove just below the aperture, seen only on casts of the interior, giving evidence of a thickening of the interior of the shell at this level.

10. *Cyrtorizoceras filosum* (Conrad)

Plate XLII, fig. 3

Cyrtoceras filosum (Conrad Mss.) Emmons, Nat. Hist. New York, Geol. 2, 392, fig. 4 (1842).

Cyrtolites filosum Hall, Pal. New York, 1, 190, pl. 41, figs. 3 a, b (1847).

Shell strongly compressed laterally and strongly curved lengthwise in a dorso-ventral plane, preserving the surface ornamentation well but not exposing the structure of the interior of the conch. At its larger end the dorso-ventral diameter is 19.5 mm., and its lateral diameter is estimated at 16 mm. About 30 mm. below the top of the specimen, measured along its longitudinal axis, the corresponding diameters are 16.5 and 13 mm.; 25 mm. farther down they are 11.2 and 9 mm.; and 25 mm. farther down they are 6 and 5 mm.; beyond which the specimen may be traced 5 mm. farther. In all of these cases the lateral diameter is an estimate, though fully half of the width of the shell is exposed. Along the upper 30 mm. of the length of the conch, the lengthwise curvature of the ventral side of the conch has a radius of about 40 mm.; along the 25 mm. in length directly beneath, the radius is about 30 mm.; along the next length of 25 mm., the radius is about 25 mm.; from this it is inferred that the apical end of the conch had a radius of lengthwise curvature of approximately 20 mm. Judging from the rate of enlargement of the lower part of the specimen the entire axial length of the specimen was about

102 to 105 mm., and along its more rapidly curved portion it partially surrounded an area of about 26 mm. in diameter. The entire shell originally probably formed about three-fourths of a volution.

The cross-section of the shell is elliptical, with the longer axis in a dorso-ventral direction, and there is a slight tendency toward angulation along the median part of its ventral side.

The surface of the shell is transversely striated by numerous fine lines which have a tendency to occur at equal intervals. Along the upper part of the specimen, along the length of 30 mm. mentioned in the preceding lines, the number of transverse lines in a length of 5 mm., measured along the middle of the lateral sides, is 8 or 9; along the 25 mm. next beneath their number is 12 to 15; along the next length of 25 mm. their number is 15 near the top and 23 at the base; and in the last 5 mm. in length, at the smaller end of the specimen, it is 30. The striae are directly transverse to the length of the conch along its dorsal side; along the lateral sides they are straight as far as the ventro-lateral part of the outline, but incline downward at an angle of 85 degrees with the vertical axis of the conch. At the ventro-lateral angles of the conch the striae begin to curve downward with increasing rapidity, descending fully 1 mm., at the base of the hyponomic sinus, below the general slope of the striae along the lateral sides of the conch. The tendency toward angulation along the median part of the ventral side increases the appearance of depth of the hyponomic sinus.

Locality and Horizon.—From Watertown, New York, in the Trenton limestone. In the description by Hall it is stated that "This species has been seen only in the higher crystalline part of the rock at Watertown, Jefferson county." The matrix, however, does not have a crystalline appearance, but is black and very fine-grained, and contains *Orthis tricenaria*, *Bumastus trentonensis* (Emmons), and a species of *Eurychilina*.

No. 817, American Museum of Natural History.

Remarks.—This species is characterized by its strong length-wise curvature, its lateral compression, the tendency toward angulation along the median part of the ventral side, and its

numerous transverse striae, curving downward at former stages of location of the hyponomic sinus.

11. *Cyrtorizoceras camurum* (Hall)

Plate XLII, fig. 4

Cyrtoceras camurum Hall, Pal. New York, 1, 196, pl. 42, fig. 6 (1847).

Specimen consisting of the living chamber with 12 camerae still attached; strongly compressed laterally and strongly curved lengthwise in a dorso-ventral plane. At the base of the living chamber the dorso-ventral diameter is 20 mm. and the lateral diameter is estimated at 14 mm. The living chamber maintains about the same dimensions for a distance of 18 mm. above its base, beyond which a moderate constriction, 4 or 5 mm. in length, takes place, but the latter feature probably is confined to the cast of the interior of the living chamber, only the cast being present, and may not occur on the exterior of the shell. Toward its apical end the conch contracts quite regularly. At the smaller end of the specimen, 34 mm. below the base of the living chamber, the dorso-ventral diameter is 14 mm. and the lateral diameter is estimated at 9 mm. The cross section of the shell is slightly more angular on the ventral than on the dorsal side. The lengthwise curvature of the ventral side of the conch has a radius of 40 mm.; the radius of curvature of the dorsal side is only slightly less. Judging from the rate of enlargement of the upper part of the phragmacone, the complete shell probably had an axial length of about 83 mm.

The number of camerae in a length equal to the dorso-ventral diameter, at the top of the series being counted, is 6, when counted along the upper part of the ventral side of the conch, and is somewhat less when counted farther down. Along the lateral sides of the conch the sutures rise but moderately from the dorsal side as far as the middle of the lateral side, but beyond this point they rise at an increasing rate, until they reach a level on the ventral side which is 4 or 5 mm. above that on the dorsal one, resulting in fairly conspicuous ventral saddles.

Locality and Horizon.—From Middleville, New York, in the lower part of the Trenton limestone; the matrix contains *Streptelasma corniculum*, *Stictopora elegantula*, *Dinorthis pectinella*, *Dalmanella* sp., *Plectambonites* sp., *Parastrophia hemiplicata*, *Ctenodonta levata*, *Phragmolites compressus*, *Kionoceras* sp. (Pal. New York, 1, pl. 56, fig. 3 (1847); Jour. Sci. Labs, Denison Univ., 19, pl. 35, fig. 2), *Oncoceras constrictum*, *Isotelus gigas*, *Ceraurus pleurexanthemus*, *Pterygometopus callicephalus*, and *Calymene* sp.

No. 816, American Museum of Natural History.

Remarks.—The figure of the type specimen published by Hall is incorrect in a variety of particulars. The slab containing the specimen is 105 mm. long and 75 mm. wide. The specimen occurs at the upper left hand corner. The living chamber is distinctly preserved and is not crossed by markings simulating the sutures on the phragmacone beneath. The lower end of the phragmacone is not broken off obliquely but terminates abruptly with one of the septa. The specimen, however, may be identified as the type by means of the flat disc-like body which overlaps the base of the living chamber and the top of the phragmacone.

Compared with *Cyrtoceras filiosum*, the rate of enlargement of the phragmacone is greater, the apical part of the conch probably is less curved, and the conch as a whole is shorter.

12. *Cyrtorizoceras whitneyi* (Hall)

Plate XLII, figs. 5A, B; 6A, B

Cyrtoceras whitneyi Hall, Rep. Superintendent Geol. Surv. Wisconsin, 39 (1861).

Cyrtoceras whitneyi Whitfield, Mem. Amer. Mus. Nat. Hist., 1, pt. 2, 65, pl. 9, fig. 5 (1895).

Two specimens were used by Hall in the description of this species. By far the larger part of his description refers to the larger specimen, including 26 camerae and parts of 2 additional ones, all still attached to the basal part of the living chamber. Whitfield, however, figured the smaller specimen, in which only 8 camerae are attached to the living chamber. References to this

smaller specimen probably are confined to the statements that the lateral diameter of this species is equal to three-fourths of the ventral diameter, and that one of the specimens preserves a portion of the shell on which fine concentric (transverse) lines of growth with more closely arranged longitudinal ridges are visible. Both specimens are regarded as belonging to the same species, but the larger one provides the better conception as to the general appearance of this species. It therefore is used here as the type, notwithstanding Whitfield's choice of the smaller specimen for purposes of figuring.

Larger Specimen.—Specimen 90 mm. in length, measured along its vertical axis. Of this length 18 mm. belongs to the living chamber, whose total height is unknown. The specimen has been strongly compressed laterally previous to fossilization. Up to within 10 camerae from the base of the living chamber, the radius of lengthwise curvature of the lower half of the ventral side of the phragmacone is 50 mm.; above this length, it is 80 mm. The radius of concave curvature along the dorsal side is about 55 mm. At the smaller end of the specimen, where there appears to be no lateral compression, the dorso-ventral diameter is 16 mm., and the lateral diameter is 13 mm. At the base of the living chamber the dorso-ventral diameter, in the present flattened condition of the specimen, is about 33 mm., with a lateral diameter of 21 mm.; before compression these two diameters may have been nearer 32 and 23 mm.

At the upper end of the phragmacone the number of camerae in a length equal to the dorso-ventral diameter at the top of the series being counted is about 8 or 9; at the lower end of the specimen this number equals 12. The sutures of the septa are only slightly concave, but they rise strongly from the dorsal toward the ventral side of the conch, the amount of this rise equalling 2 camerae near the middle of the specimen and 3 camerae at the top of the phragmacone, resulting in distinct ventral saddles. The siphuncle is almost in contact with the ventral wall of the shell. The interior of the shell is marked by numerous equidistant vertical ribs, of which 7.5 occur in a width

of 10 mm. near mid-length of the specimen. The siphuncle is moniliform, and situated close to the ventral wall of the conch.

The shell is very thick, equalling in places three-fourths of a millimeter. Its surface appears to have been relatively smooth. At least, it shows no trace of vertical ribbing.

Smaller Specimen.—This specimen consists of the lower part of the living chamber with 8 camerae still attached. Of the living chamber a length of 14 mm. can be detected, its original length being unknown. The upper part of this living chamber appears to flare outward, as in *Cyrtorizoceras minneapolis*, or even more than in that species; however, owing to the distortion of the specimen the evidence is not clear. Along the ventral side the radius of lengthwise curvature is 60 mm., that on the dorsal side being about 30 mm. At the smaller end of the specimen the dorso-ventral diameter is 19 mm., the lateral diameter being estimated at 16 mm. The number of camerae in a length equal to the dorso-ventral diameter at the top of the series being counted is about 9. The sutures of the septa rise from the dorsal toward the ventral side a distance of two and a half camerae, at the top of the phragmacone.

Of the shell only a thin film is preserved. This does not show the distinct vertical ribs, seen on the interior of the longer specimen, excepting possibly in a very obscure manner. Instead, there are fine vertical striae, numbering 18 in a width of 5 mm. near the top of the phragmacone. There are also traces of transverse striae, which curve increasingly downward from the dorsal toward the ventral side a total distance of three and a half camerae. However, since both of these features, the vertical and the transverse striae, are shown by the surface of only a thin film covering the cast of the interior of the conch, through which the sutures of the septa may be seen distinctly, it is by no means certain that they are an index of the character of the surface ornamentation of the shell. While the surface of the shell probably shows transverse striae similar to those here described there may be none of the vertical striae present there. Apparently the number of transverse striae in a length of 5 mm. is about 12, but these striae are too indistinct for accurate counting.

Locality and Horizon.—From Maquoketa creek, 12 miles northwest of Dubuque, in Iowa, in the Maquoketa member of the Richmond formation.

No. 1400, American Museum of Natural History.

Remarks.—This species probably is related closely to the *Cyrtoceras* figured by Clarke from the Black River of Wisconsin under the name *Cyrtoceras canurum*, but it enlarges much more rapidly in a dorso-ventral direction.

13. *Cyrtorizoceras multicameratum* (Hall)

Plate XLV, fig. 4

Cyrtoceras multicameratum Hall, Pal. New York, 1, 195, pl. 42, fig. 4 (1847).

Specimen badly distorted by compression which is chiefly lateral but also slightly oblique; in addition the conch was broken across at three places along the smaller end of the specimen, and the parts were bent out of alignment to varying degrees. The result is that little can be affirmed with exactness beyond the fact that the camerae are of small height, and therefore are relatively numerous.

The upper part of the specimen, for a length of 25 mm., appears to have had a lengthwise curvature with a radius of 50 mm. along its ventral side, while along its dorsal side the radius of curvature was about 25 mm. At one of the breaks the dorso-ventral diameter is 13 mm.; 10 mm. farther up it is 15 mm.; and an additional distance of 10 mm. farther up it is 19 mm.; a rate of enlargement of 2.8 mm. in a length of 10 mm. appears to be indicated by that part of the shell which seems least distorted. Where the dorso-ventral diameter is 13 mm. the lateral diameter is estimated to have been at least 11 mm., as far as can be determined from the present condition of the specimen.

The sutures rise strongly from the dorsal toward the ventral side of the conch, the amount of this rise equalling the height of 2 camerae, measured along its ventral side. The lateral lobes, though strongly inclined, are of small depth. The number of camerae in a length equal to the dorso-ventral diameter is 9.

Locality and Horizon.—From Middleville, New York, in the lower part of the Trenton limestone. The matrix contains numerous specimens of *Plectambonites*.

No. 820, American Museum of Natural History.

Remarks.—It is impossible to determine more from the specimen at hand. In the number of its camerae and their considerable rise from the dorsal toward the ventral side, this specimen resembles some forms of *Manitoulinoceras*, but in that case it should be dorso-ventrally depressed, instead of laterally compressed.

14. *Cyrtorizoceras* sp. (Carlisle, Pa.)

Plate XLIII, fig. 6

Cyrtoceras macrostomum Hall (but not the type of the species), Pal. New York, 1, 194, pl. 41, fig. 1a (1847).

Conch slightly compressed laterally, its dorso-ventral diameter being 9.2 mm., while its lateral one is only 8.5 mm. at the smaller end of the specimen; enlarging to a dorso-ventral diameter of 14 mm. at a point 22 mm. farther up. Six camerae occur in a length equal to the dorso-ventral diameter of the conch. Septa rising strongly in a ventral direction. Lateral lobes of sutures of the septa very shallow. Surface of shell apparently smooth.

Locality and Horizon.—Carlisle, Pennsylvania; in the Trenton. No. 822-1, American Museum of Natural History.

15. *Zitteloceras hallianum* (D'Orbigny)

Plate XLIII, figs. 3 A, B

Cyrtoceras lamellosum Hall (not Verneuil, 1842), Pal. New York, 1, 193, pl. 41, figs. 2 a-c (1847).

Cyrtoceras hallianus D'Orbigny, Prodr. Pal., 1, 1, (1849).

Zitteloceras hallianum Foerste, Jour. Cincinnati Soc. Nat. Hist., 22, 51, pl. 3, figs. 5 A, B (1917).

Compared with *Zitteloceras beloitense* Foerste the size of the conch is smaller; the living chamber is shorter and more contracted toward the aperture, especially ventrally; the number of camerae is relatively greater, but the number of transverse

lamellae is about the same. The margins of these lamellae are conspicuously more wavy.

Locality and Horizon.—Middleville, New York, in the Trenton limestone.

No. 823, American Museum of Natural History.

16. *Zitteloceras beloitense* Sp. nov

Plate XLIII, figs. 2 A-D

Cyrtoceras neleum Hall, Rep. Superintendent Geol. Surv. Wisconsin, 40, (1861). (Only the specimen from Beloit, Wisconsin, which is one of the two specimens used in the original description of *Cyrtoceras neleum*, but which is not congeneric with the type of that species, which is from Platteville, Wisconsin.)

Cyrtoceras tenuistriatum Whitfield, Mem. Amer. Mus. Nat. Hist., 1, pt. 2, pl. 9, fig. 12 (1895).

Cf. *Zitteloceras hallianum* Foerste, Jour. Cincinnati Soc. Nat. Hist., 22, 51, pl. 3, figs. 5 A, B (1917).

Conch strongly curved in a dorso-ventral plane; the convex curvature of the ventral side has a radius of 25 mm.; the concave curvature of the dorsal side has a radius of 20 mm. At the base of the specimen, 15 mm. below the base of the living chamber when measured along the ventral side, the cross-section of the conch is circular, with a diameter of 10.5 mm. The cross-section is circular also 5 mm. above the base of the living chamber, where the diameter is 13 mm. Just beneath the aperture, however, where the dorso-ventral diameter still is 13 mm., the lateral diameter is 12 mm. Measured along its ventral side, this living chamber has a height of 18 mm. The total length of a complete specimen is estimated at 65 mm.

Along the living chamber, the conch is slightly more narrowly rounded on the ventral than on the dorsal side. Along the dorsal side of the conch the margin of the aperture is directly transverse; on the lateral sides it curves increasingly downward on approaching the ventral side, and along the median part of the latter it curves strongly downward, producing a hyponomic sinus about 4 mm. wide and 2 mm. deep, the margin flaring outward at this

sinus nearly 1 mm. It is possible, judging from the surface markings beneath, that the margin flared outward along the entire circumference of the aperture, but the amount of this flaring is known only at the hyponomic sinus.

The sutures of the septa are directly transverse on the dorsal side of the conch; on the lateral sides they curve increasingly upward on approaching the median parts of the ventral side, resulting in lateral lobes and ventral saddles. Measured along the ventral side of the conch, each of the lower 4 camerae occupies a length of 3 mm., followed by a fifth camera 1.5 mm. long, and a sixth camera 2 mm. long. Owing to this shortening of the upper camerae, the specimen is regarded as mature. The radius of concave curvature of the septa is 7.5 mm. The siphuncle is barely in contact with the ventral wall of the conch. A single segment projects beneath the base of the specimen; its outline is slightly fusiform, indicating a moniliform siphuncle, and its lateral diameter is 1.5 mm.

The surface of the conch is marked by prominent transverse ridges, locating the position of successive stages of the aperture. The maximum height of these ridges is about one-third of a millimeter, but their original height may have been greater. Their direction has been indicated above, in describing the margin of the aperture of the conch. While, on close inspection, these transverse ridges are seen to be slightly wavy, the amount of this wavy curvature is so insignificant as to be overlooked readily. No intermediate finer striae can be detected.

Locality and Horizon.—From the "Buff limestone" or Black River limestone, at Beloit, Wisconsin. No. 992, American Museum of Natural History.

Remarks.—The following parts of the original description of *Cyrtoceras neleum* apply to *Zitteloceras beloitense*:

"Shell of small size. Surface marked by transverse, slightly undulating annulations, which are strongly and abruptly curved backward on the dorsum (ventral side). This species differs from *C. lamellosum*, Hall (1847).—*C. Halleanus*, D'Orbigny (1850)—*B. Billingsi*, Salter (1859) (Canadian Organic Remains, Decade I.), not *C. lamellosum* of De Verneuil (1842)."

From *Zitteloceras hallianum* D'Orbigny, from the Trenton limestone at Middleville, New York, this species differs in the following particulars: The conch, at maturity, is larger. The living chamber relatively is longer, and is not contracted near the aperture, especially on its ventral side. The number of camerae relatively is less, but the number of transverse ridges is about the same. The greatest difference is in the amount of waviness of the transverse ridges, which relatively is slight.

17. *Zitteloceras percurvatum* Sp. nov.

Plate XLIII, figs. 1A, B, C

The shell is coiled rapidly in a dorso-ventral plane. The complete shell must have exceeded one volution in length, possibly by as much as one fourth or one third of a volution. It enclosed an open space of about 11 mm. in diameter. The specimen consists of the living chamber with part of the phragmacone still attached. The axial part of the living chamber is 21 mm. in length. Beneath this are 5 camerae with an axial length of almost 10 mm. Beyond this the dorsal side of the shell continues for a distance equal to an axial length of 23 mm. The diameter across the entire volution at right angles to the lower part of the living chamber probably was about 34 mm. The shell was depressed dorso-ventrally. At the larger end of the living chamber the dorso-ventral diameter is 16 mm., and the lateral diameter is estimated at about 17 mm. At the base of the living chamber the corresponding diameters are 13 and 14.5 mm. about 9.5 mm. beneath the living chamber the dorso-ventral diameter is 12 mm., but here the shell was compressed laterally before fossilization.

Only the two upper septa can be traced all the way from the dorsal to the ventral side. If the camerae beneath were of about the same size as the uppermost one, then the number of camerae along the ventral side in a distance equal to the dorso-ventral diameter at the top of the series of camerae being counted would exceed 5 slightly. However, only the 3 uppermost camerae are of approximately the same size and the 2 next below are distinctly

shorter. The sutures rise from the dorsal toward the ventral side at an increasing rate so as to produce very broad and shallow lateral lobes, the ventral saddles rising 2 mm. above the level of the sutures on the dorsal side of the shell. The dorso-ventral curvature of the septa is moderately greater than that of the sutures, but the lateral curvature of the septa is much less.

The surface of the shell is ornamented by wavy or frilled lamellose transverse striae which extend outward from the shell for a distance of half a millimeter, and which rise slightly above the horizontal, forming an angle of 80 degrees with the vertical axis of the conch. Along the upper part of the phragmacone these striae curve increasingly downward, from the dorsal toward the ventral side, especially near the median line of the latter, where the striae are about 2 camerae lower than on the dorsal side. Along the upper part of the living chamber the striae curve only slightly downward except along the median part of the ventral side where they curve downward for a distance of 1 mm. or slightly farther. The striae vary greatly in number, apparently in an irregular manner, varying from 7 to 10 or 11 in a length of 5 mm. They are least numerous along the upper part of the phragmacone and the lower part of the living chamber, and are distinctly more numerous along the upper half of the living chamber. They tend to alternate in size; this is discovered on filing off the matrix surrounding the conch, and it might not be noticed so readily in specimens free from the matrix. Six and a half frills occur in a width of 5 mm.

Locality and Horizon.—From Mineral Point, Wisconsin, in the Platteville limestone. The matrix of this specimen is light blue, or light grey, with a slightly brownish tint, as in some of the Plattin limestone layers.

No. 995, American Museum of Natural History, where it is labelled *Cyrtoceras tenuistriatum* Hall.

Remarks.—This species is characterized by the very rapid curvature of the conch, exceeding that of a whole volution.

In the specimen here described the transverse striae are represented both by the transverse lines of growth marking the matrix filling the interior of the conch, evidently corresponding to similar

markings on the interior of this conch, and also by the frilled lamellae which at rhythmic intervals project outward for a distance of half a millimeter from the surface of the shell, nearly at right angles to the latter. The transverse striae first mentioned are much less undulated than the outer margin of the projecting lamellae, indicating that these outer margins are more frilled than the lines of junction of these lamellae with the surface of the shell.

18. *Zitteloceras* (?) *tenuistriatum* (Hall)

Plate XLIII, figs. 4A, B

Cyrtoceras corniculum Hall, Rep. Geol. Surv. Wisconsin, 41, figs. 1, 2 (1862).

Cyrtoceras tenuistriatum Hall, in Miller's Amer. Pal. Foss., 243 (1877).

Conch strongly curved lengthwise in a dorso-ventral plane. Only a fragment of the phragmacone is present and the curvature of this fragment varies from a radius of 20 mm. along the lower two-fifths to a radius of 25 mm. along the upper three-fifths of its length, along its ventral outline. Along the dorsal outline the radius of curvature is 15 mm. The dorso-ventral diameter varies from 5 mm. at the smaller end of the specimen to 14 mm. at its larger end, the axial length of the specimen being 45 mm. At its smaller end, the cross-section of the specimen is circular in outline, but at the larger end its lateral diameter is 16 mm., contrasting distinctly with 14 mm. which is its dorso-ventral diameter at this point. The shell, therefore, is depressed, and this is true notwithstanding the fact that the median part of the ventral side is distinctly, though broadly, angulated, the angulation taking in the entire width of that part of the shell along which the downward flexure of the transverse striae indicates former locations of the hyponomic sinus. At the top of the specimen this width includes nearly 4 mm. Along the dorsal side of the specimen, on the contrary, there is a slight tendency toward flattening.

At the smaller end of the specimen the septum is very slightly concave; at its top it is rather strongly concave. The septum rises strongly from the dorsal toward the ventral side of the

conch. The siphuncle is rather indistinctly indicated. It is about 0.8 mm. in diameter, and it is about 1.5 mm. distant from the ventral surface, as near as can be determined from this type specimen. Nothing is known about the distance between the septa nor of the form of the segments of the siphuncle.

The surface of the shell is striated transversely, the striae being relatively coarse and prominent. About 11 striae occur in a length of 5 mm. along the ventral side of the larger end of the specimen. Along the dorsal side they are more crowded, and are directly transverse to the length of the shell. Along the lateral sides they slope only slightly downward, but along the median part of the ventral side, for a width of 6 or 7 mm., these striae curve downward, forming a broad hyponomic sinus about 1 mm. in depth. In addition to the transverse striae, the shell is transversely annulated, the number of annulations varying from 3 in a length of 5 mm. to 3 in a length of 10 mm. along different parts of the upper half of the conch. These annulations coincide in direction with the transverse striae, curving downward at the hyponomic sinus. The transverse annulations may not occur in all specimens of this species. The transverse striae are not wavy as in typical *Zitteloceras*.

Locality and Horizon.—From Mineral Point, Wisconsin, in the Platteville limestone. The specimen is of a yellowish brown color, and not of the light blue tint found in the Platin limestone.

No. 995, American Museum of Natural History.

Remarks.—*Cyrtoceras tenuistriatum* belongs to that group of cyrtoceroids which resemble *Zitteloceras* in the distinct downward flexure of the transverse striae along the median part of the ventral side, but in which the striae are much closer together, are not extended into free lamellae, and are not frilled.

19. *Centrocyrtoceras subannulatum* (D'Orbigny)

Cyrtoceras annulatum Hall, Pal. New York, 1, 194, pl. 41, figs. 4 a-d, 5 (1847).

Cyrtoceras subannulatum D'Orbigny, Prodr. Pal. 1, 1 (1849).

Centrocyrtoceras subannulatum Foerste, Jour. Sci. Lab. Denison Univ., 21, 366, pl. 45, figs. 4 A-C (1926).

Conch small, strongly curved lengthwise, enlarging fairly rapidly, and crossed transversely by annulations and numerous fine striae. The conch apparently formed about three-fourths of a volution, partly surrounding an open space about 10 mm. in diameter. The entire conch was at least 42 mm. long, measured along its central axis. The conch enlarged at an apical angle of about 15 degrees. At its larger end the conch attained a diameter of at least 13 mm., the cross-section being circular. The general lengthwise curvature of the conch had a radius of 15 mm. along its convex outline, decreasing to 10 mm. toward its apical end, and increasing to 25 or 30 mm. toward the aperture. The siphuncle is central in location, or slightly ventrad of the center.

It is not possible to determine from the specimens at hand the number of camerae in a given length. The average number of annulations in a length equal to the diameter of the conch is 5, increasing to 7 or 7.5 toward its upper end, where the annulations are more crowded. The annulations rise in a ventrad direction an amount varying from half the distance between successive annulations to fully this distance. However, along the middle of the lateral sides of the conch these annulations curve more or less distinctly downward, introducing a sinuosity similar to that of *Orthoceras arcuoliratum* Hall, from the same locality and horizon. The number of transverse striae in a length of 1 mm. numbers 7 or 8 in the specimen represented by Hall's figures 4 b-d, but only 3.5 to 4 in his specimen represented by figure 5. Possibly 5 transverse striae in a length of 1 mm. is the average. No vertical striae can be detected.

Locality and Horizon.—Middleville, New York, in the lower part of the Trenton limestone. The matrix apparently contains *Ephippiorthoceras subarcuatum* D'Orbigny, originally described from the same locality under the name *Cyrtoceras arcuatum* by Hall under the misapprehension that he was dealing with a cyrtoceroid.

No. 821, American Museum of Natural History.

Remarks.—Accompanying his original description, Hall published figures of 3 specimens, one from the higher crystalline parts

of the Trenton as exposed at Watertown, and the other two from the lower part of the Trenton at Middleville. Under *position and locality*, Hall mentioned the Middleville locality first, and in his figures he illustrated one of these Middleville specimens more fully than the rest. On this account the Middleville specimen illustrated by his figures 4 b-d is selected here as the type.

20. *Manitoulinoceras neleum* (Hall)

Plate XLV, figs. 3 A-C

Cyrtoceras neleum Hall, Rep. Superintendent Geol. Surv. Wisconsin, 40 (1861); also Whitfield, Mem. Amer. Mus. Nat. Hist., 1, pt. 2, 65, pl. 9, figs. 10, 11 (1895).

Conch strongly curved lengthwise, the radius of curvature of the convex ventral side being 40 mm. and that of the concave dorsal side 25 mm. At the base of the specimen the dorso-ventral diameter is 16 mm., and the lateral one is 15 mm. At the base of the living chamber the corresponding diameters are 18 and 17 mm., the intervening distance being 37.5 mm. when measured along the ventral outline of the conch. Judging from this small rate of enlargement, the conch may have been more than one revolution in length, but in that case it was gyroceraconic. The ventral side is more narrowly rounded than the dorsal one.

When counted along the ventral outline of the conch, 7.5 camerae occupy a length equal to the dorso-ventral diameter at the smaller end of the specimen, increasing to 8.5 camerae in a corresponding length farther up. The last 3 camerae occupy a total length of 4 mm., contrasting strongly with the total length of 6 mm. farther down. The shorter length of these upper camerae suggests that the conch was fully mature. Along the median part of the dorsal side of the conch the sutures of the septa curve slightly upward, from slightly less than half a millimeter near the base of the specimen to nearly a whole millimeter near the top of the phragmacone. The resulting dorsal saddles are about 6 mm. wide. It is not certain that these saddles are characteristic of all individuals of this species. On the lateral sides of the conch the sutures of the septa curve increasingly

upward in a ventrad direction, the amount of the upward slant increasing toward the top of the phragmacone; however, the downward curvature of the sutures of the septa along the lateral sides of the conch becomes less in the same direction. The siphuncle is almost in contact with the ventral wall of the conch.

The type is a cast of the interior of the conch. Its surface is marked by faint vertical ribs, about 2.5 mm. apart on most of the circumference of the specimen. Where the sutures cross these ribs they curve slightly upward. The result is a wavy appearance of these sutures, which has nothing in common with the wavy course of the outer margins of the transverse lamellae on the surface of the shell of *Zitteloceras beloitense*, with which Hall associated this type.

Locality and Horizon.—Platteville, Wisconsin, from the Platteville member of the Black River formation.

No. 992-2, American Museum of Natural History.

Remarks.—This species is characterized by its very small rate of enlargement, and its relatively low camerae. Of the original description of *Cyrtoceras nelem*, the following applies to the specimen here chosen as type:

"Shell of medium size, very gradually expanding from the apex and strongly curved, transverse section circular, or sub-circular, very obtusely sub-angular on the back in casts, most ventricose on the ventro-lateral (now called dorso-lateral) region. Septa closely but not evenly arranged, averaging about nine in a space equal to the transverse diameter of the shell, curving forward on the dorsal (ventral) side, their margins undulated especially towards the outer chamber where they became crowded. On the ventral (dorsal) side the septa have a broad advancing curve. The exposed surface of the septa (basal septa) shows the greatest concavity a little on the ventral (dorsal) side of the center. Siphuncle dorsal (ventral), comparatively large. Diameter of large specimens five-eighths of an inch. This species differs in the more gradual and even curvature, the much less rapid expansion, (the expansion being only one-sixteenth of an inch in a length of one inch and a quarter)."

This species is similar to *Manitoulinoceras lysander* (Billings), in

the small rate of enlargement of the conch, in the shortness of the camerae, and in the increasing rise of the sutures of the septa in a ventrad direction, on approaching the top of the phragmacone. It is not certain that the segments of the siphuncle are similar in structure. It differs from the Manitoulin species, however, in being slightly compressed laterally, instead of depressed dorso-ventrally.

21. *Manitoulinoceras middlevillense* Sp. nov.

Plate XLIII, figs. 5 A, B, C

Cyrtoceras macrostomum Hall (not the type of *macrostomum*), Pal. New York, 1, pl. 42, figs. 3a, b (1847).

The small fragment of the phragmacone here described is 20 mm. long, and is distorted by compression at the top. At its lower end its width is 13 mm. and its dorso-ventral diameter is 12 mm., indication a slight dorso-ventral depression. Farther up, the corresponding diameters are 14.2 mm. and 13 mm. respectively. The radius of curvature of the convex ventral outline is 25 mm. and that of the concave dorsal outline is 15 mm. Six camerae occur in a length equal to the dorso-ventral diameter of the conch. The septa curve increasingly upward in a ventrad direction, rising nearly the height of two camerae, although the lateral lobes are very shallow. The sutures of the septa are exposed, but not the septa nor the siphuncle. A single valve of *Pholidops trentonensis* is found near the spot where the siphuncle should be. The surface of the shell is ornamented by raised transverse lines which curve increasingly downward in a ventral direction, indicating former stages of growth of the shell along a broad and relatively shallow hyponomic sinus. At rhythmic intervals the striae are of larger size, 10 of these larger striae occurring in a length of 5 mm. along the middle of the lateral sides of the specimen. The intermediate striae are finer and more numerous, 2 or 3 finer striae occurring between each two of the larger ones.

Locality and Horizon.—Middleville, New York, in the Trenton limestone.

No. 822-2, in the American Museum of Natural History.

Remarks.—This species agrees with *Manitoulinoceras lysander* (Billings) in its dorso-ventral depression, the small height of the camerae and the strong upward curvature of the sutures of the septa. It differs, however, in the distinct downward curvature of the transverse striae in a ventrad direction, and in the much more distinct hyponomic sinus. It differs from *Zitteloceras tenuistriatum* (Hall) in the distinct downward curvature of the transverse striae laterally, and in the much greater width and less abrupt downward curvature of these striae at former stages of the hyponomic sinus.

22. *Oncoceras abruptum* Hall

Plate XLV, figs. 2 A, B; probably not 1 A, B

Oncoceras abruptum Hall, Rep. Superintendent Geol. Surv. Wisconsin, 44, (1861).

Oncoceras abruptum Whitfield, Mem. Amer. Mus. Nat. Hist., 1, pt. 2, 68, pl. 10, figs. 1-3 (1895).

The type specimen consists of the lower part of a living chamber with 10 camerae still attached. The ventral side of the phragmacone has a radius of curvature of 50 mm., changing to about 40 mm. along the lower part of the living chamber. The lower part of the dorsal side of the phragmacone, for a length of 5 camerae, has a concave lengthwise curvature with a radius of 30 or 40 mm., changing along the upper part of the phragmacone and the lower part of the living chamber to a convex lengthwise curvature with a radius of 50 mm. At a distance of 10 mm. above the base of the living chamber, the dorsal outline apparently changes to concave again on approaching the aperture. The dorso-ventral diameter enlarges from 12 mm. at the base of the specimen to 24 mm. at the base of the living chamber, reaching its maximum of 25 mm. about 3 or 4 mm. above the base of the living chamber. The most gibbous part of the conch, therefore, is about on line with the base of the living chamber on its ventral side, and 3 or 4 mm. above this base on the dorsal side. At the base of the specimen the lateral diameter is 11 mm., reaching 22

mm. at the base of the living chamber, showing a moderate lateral compression in both cases.

The number of camerae in a length equal to the dorso-ventral diameter at the top of the series being counted is 10, when counted along the ventral side of the specimen. The sutures of the septa are straight, and rise from the dorsal toward the ventral side a distance of 1 or 1.5 camerae, toward the top of the phragmacone, while toward the base of the specimen these sutures are almost directly transverse to the vertical axis of the specimen. In consequence the ventral length of that part of the phragmacone which is at hand is 24 mm., while the dorsal length is 18 mm. The septa are gently concave. The siphuncle is about 2 mm. in width, and parts of it are in contact with the ventral wall of the shell.

Only the cast of the interior of the conch is at hand, and this presents faint traces of vertical ribs. These number about 8 in a width of 11 mm. at the top of the phragmacone. There is no evidence that the outer surface of the shell was marked vertically, since such markings often are confined to the interior of the conch.

Locality and Horizon.—From Platteville, Wisconsin, in the Platteville member of the Black River. In a dense, fine-grained matrix resembling the Plattin limestone.

No. 997-2, American Museum of Natural History.

Remarks.—Compared with *Oncoceras constrictum*, this species is less curved lengthwise, and the gibbosity along its dorsal side is less conspicuous, because the phragmacone enlarges less abruptly at the base of the gibbous part.

Beloit specimen.—This specimen may not belong to the same species as the type described above. When figured by Whitfield it consisted of 9 camerae. At present the upper 4 camerae figured by Whitfield are missing, but the septum at the top of the remaining portion is fully exposed. Here the dorso-ventral diameter is 18.5 mm., and the lateral one is 15 mm. At the base of the specimen this diameter is only 15 mm. The sutures of the septa are directly transverse along the dorsal half of the conch, but curve upward slightly along its ventral half. The septa are only moderately concave. The siphuncle is almost in contact with the

ventral side of the conch. Its diameter within the uppermost camera still preserved is 1.5 mm. The specimen consists of a cast of the interior of the conch, and this cast is marked by 8 vertical ribs within a width of 10 mm. The lengthwise curvature of the ventral outline in this specimen has a radius of only 25 mm., instead of 50 mm. as in the type described above.

Locality.—From Beloit, Wisconsin.

No. 997, American Museum of Natural History.

23. *Deiroceras distans* (Hall)

Plate XL, fig. 2

Endoceras distans Hall, Pal. New York, 1, 220, pl. 58, figs. 1 a, b (1847).

Specimen 215 mm. in length, consisting of 10 camerae. The specimen was crushed laterally before fossilization. In its present condition its rate of enlargement in a dorso-ventral direction is at an apical angle of 5 degrees. The dorso-ventral diameter of the conch at the base of the specimen is estimated at 40 mm. Originally the cross-section of the conch may have been circular; where it is least crushed the ratio of the lateral diameter to the dorso-ventral one is about 95 per cent. Along the lower part of the specimen, where it is least crushed, slightly more than 2 camerae occur in a length equal to the dorso-ventral diameter of the conch. Along its upper part, where distinctly crushed, 2.5 camerae occur in a corresponding length. Possibly this is an indication that the conch was approaching maturity, although the actual length of the camerae along the entire specimen remains persistently about 20 mm. The sutures of the septa slope downward, at a small angle, from the dorsal toward the ventral side of the conch. This slope also may not be a constant feature of the species. The concavity of the septa is about 7 or 8 mm. The siphuncle is very close to the ventral wall of the conch, but may not be in actual contact with the latter, being separated possibly by a distance of less than 1 mm. At the base of the specimen, where the camerae are 20 mm. in height, and 40 mm. in diameter, the segments of the siphuncle enlarge from a diameter of 9 mm.

at the septal necks to 16 mm. at mid-height within the camerae. Their maximum diameter, therefore, equals two-fifths of the diameter of the conch. In vertical section their outlines are elongate elliptical, but slightly truncated at top and bottom. The three lower camerae have been sectioned vertically in a lateral direction. This has exposed an endosiphuncle, filled with matrix, varying from 2.5 to 4 mm. in diameter, and occupying the center of the siphuncle. The remainder of the interior of the siphuncle is filled with calcite. By far the greater part of this calcite belongs to the original calcareous deposit which enveloped the inner wall of the septal necks, and continued to grow lengthwise, as well as inward, until these deposits came within a distance of less than 2 mm. from each other at mid-height of the segments of the siphuncle. At present the intervening distance is occupied by a whiter and more crystalline calcite. The exterior of the calcareous deposit filling the interior of the fifth segment from the base of the siphuncle is exposed, and shows the irregular vertical grooving so often seen in Actinoceroid conchs. The surface of the shell, apparently, was smooth.

Locality and Horizon.—Turin, New York; in the Trenton limestone.

Specimen No. 800, American Museum of Natural History.

Remarks.—The Actinoceroid structure of the deposits within the siphuncle associated with a vertically elongate form of the segments of the latter, is the distinctive feature of this species. Compared with *Deiroceras python* (Billings), from the Trenton at Ottawa and Montreal, in Canada, the segments of the siphuncle are more elongated vertically, compared with their diameter.

CONRADOCERAS Gen. nov.

Genotype: *Cyrtoceras macrostomum* Hall.

Conch resembling *Rizoceras* in its rapid enlargement, but with distinctly nummuloidal segments of the siphuncle. Other differences of minor significance are the greater lengthwise curvature of the conch, and the absence of downward curvatures of the margin of the aperture along the median part of its dorsal

and ventral outlines. Compare with *Rizoceras indocile* (Barrande), the genotype of *Rizoceras*, in the Journal of the Scientific Laboratories of Denison University, vol. 21, pl. 34, fig. 3 A-E, or directly with Barrande, Systeme Silurien du Centre de la Boheme, 2, pt. 3, pl. 185. Named in honor of Conrad who first described the genotype under *Cyrtoceras marginalis*, a name preoccupied by Phillips

24. *Conradoceras macrostomum* (Hall)

Plate XLIV, figs. 1 A, B, C

Cyrtoceras marginalis Conrad, Proc. Acad. Nat. Sci. Philadelphia, 1, 334 (1843).

Cyrtoceras macrostomum Hall, Pal. New York, 1, 194, pl. 42, figs. 1 b, c (1847).

Specimen 100 mm. in length, measured along its vertical axis. In this distance an axial length of 45 mm. belongs to the living chamber; the remaining length is occupied by 24 camerae. The conch is curved moderately lengthwise. Along the lower 12 camerae the radius of lengthwise curvature along the ventral side is about 50 mm., changing to 150 mm. along the upper 12 camerae, and 200 mm. along the living chamber. Along the dorsal side of the conch, the radius of lengthwise curvature is about 60 mm. along the lower part of the phragmacone, changing to 100 mm. along its upper part and becoming almost straight along the living chamber. At the base of the specimen, its dorso-ventral diameter is 12.5 mm., increasing to 23 mm. in an interval of 12 camerae, to 36 mm. at the base of the living chamber, and to about 50 mm. at the top of the living chamber. The lateral diameter at the base of the living chamber is 31 mm., contrasting with a dorso-ventral diameter of 36 mm., and the same ratio between the two diameters is shown also at the base of the specimen and at its top. The conch enlarges regularly as far as the aperture, the rate of enlargement decreasing slightly at mid-height of the living chamber in a lateral direction.

There is no shortening of the camerae just beneath the living chamber, so that the specimen may not be fully mature. The

number of camerae in a length equal to the dorso-ventral diameter of the conch at the top of the series of camerae being counted is 12, when counted along the ventral side. Near the top of the phragmacone, the siphuncle attains a width of 8 mm., and here its segments incline downward so strongly toward the interior as to suggest that the septa are fairly strongly concave; at the base of the specimen, however, the septa are only moderately concave. The segments of the siphuncle are broadly nummuloidal, compared with their height, and they are sufficiently flattened along their ventral sides to indicate that they were in contact with the ventral wall of the conch.

Judging from transverse markings on the cast of the interior of the living chamber, the entire specimen being a cast, the exterior of the shell may have been striated transversely, but there is no trace of a hyponomic sinus, unless this sinus was very shallow.

Locality and Horizon.—From Mineral Point, Wisconsin, in the Platteville member of the Black River limestone. The matrix contains *Strophomena filitexta*.

No. 822-3, American Museum of Natural History.

Remarks.—This species is characterized by its large living chamber, not contracting toward the aperture, and its strongly nummulitic siphuncle, located along the ventral wall of the conch.

25. *Diestoceras alceum* (Hall)

Plate XLIV, figs. 2 A, B

Oncoceras alceum Hall, Rep. Superintendent Geol. Surv. Wisconsin, 46 (1861); also Whitfield, Mem. Amer. Mus. Nat. Hist., 1, pt. 2, 70, pl. 9, figs. 23-26 (1895).

Specimen 59 mm. long, of which length 25 mm. belongs to the living chamber. The specimen was depressed obliquely before fossilization, so that the siphuncle is located at present about half way between the median line of one of its broader faces and its right side. The specimen originally was nearly straight. Its ventral side was gently convex along its entire vertical outline. The dorsal outline also is gently convex along almost its entire

length, but may have been faintly concave toward the base of the phragmacone. The ventral outline of the phragmacone is 34 mm. long, its dorsal outline being 30.5 mm. At present the largest diameter at the base of the living chamber is 32 mm., shortening to 28 mm. at the aperture. The shortest diameter at the base of the living chamber is 23 mm., but originally the lateral compression of the conch probably was much less.

The specimen is a cast of the interior of the conch. This cast enlarges slightly within 1 mm. from its top, but it is possible that the shell merely thinned here, and that its exterior did not enlarge appreciably. At the base of the cast of the interior of the living chamber is a groove which is an impression of the attachment ring by means of which the animal was fastened to the conch. This groove is ribbed vertically, 6.5 ribs occurring in a width of 10 mm. These ribs are more distinct ventrally than dorsally. Corresponding, but very faint, vertical ribs are scarcely discernible on the phragmacone. The sutures of the septa are straight. Those at the base of the specimen form an angle of 10 degrees with that at the base of the living chamber, suggesting a corresponding curvature of the longitudinal axis of the conch. The uppermost camera is distinctly shorter than those directly beneath, thus indicating that the animal had reached full maturity. There are 15 camerae, and of these 14 occupy a length equal to the maximum diameter of the conch.

The siphuncle is relatively large, its diameter varying from slightly over 3 mm. at its base to 6 mm. at its top. Its distance from the ventral wall of the conch varies from one-half to a whole millimeter at corresponding points. The segments of the siphuncle appear as annulations when viewed from their dorsal or lateral sides, but ventrally their vertical outline is almost straight. These segments slant at an angle of 25 degrees with the horizontal toward the center of the conch. Before the distortion of the conch their slope may have been less. Where the segments are 6 mm. in diameter, the septal necks are only 2.8 mm. in diameter. Their general form is nummuloidal.

The dorsal side of the cast of the interior of the living chamber is marked by raised transverse lines, about 6 or 7 in a length of 10 mm., regarded as lines of growth of the shell. These lines

slope at an angle of 7 degrees with the sutures at the base of the living chamber, in a dorsad direction.

Locality and Horizon.—Beloit, Wisconsin; in the "Buff limestone" of the Black River formation, probably from the Platteville member.

No. 1000, American Museum of Natural History.

Second specimen figured by Whitfield.—Six camerae remain attached to the living chamber. The specimen was strongly compressed previous to fossilization, and the siphuncle is close to the more flattened side. The sutures of the septa are straight. The camerae are slightly longer ventrally than dorsally, 6 camerae occurring in a length of 14 mm. along the ventral side, while dorsally they occupy 13 mm. The rate of increase of this conch in size is less than in the type.

No. 1000-B, American Museum of Natural History.

ULRICHOCERAS Gen. nov.

Genotype: *Ulrichoceras beloitense* Foerste

Conch gomphoceroid in general appearance, contracting along the upper half of the living chamber, chiefly laterally but also, to a lesser extent, dorsally. The aperture remains widely open. The siphuncle is located near its concave ventral outline, the dorsal outline being convex, and the conch endogastric. The segments of the siphuncle are distinctly nummuloidal, appearing like low flattened disks. The sutures of the septa are directly transverse dorsally and laterally but curve distinctly downward along the median part of the ventral side.

This genus is of special interest since it is the only gomphoceroid endogastric genus of cephalopods known at present from the Ordovician. Named in honor of Dr. E. O. Ulrich, a leading American paleontologist.

26. *Ulrichoceras beloitense* Sp. nov.

Plate XLVII, figs. 1A-C

The little that is known at present regarding this species is included in the generic description. More exact details, accompanied by photographic figures, will follow.

Locality and Horizon.—Beloit, Wisconsin; in the Beloit member of the Black River.

No. 25302, U. S. National Museum.

27. *Orthoceras multiseptum* Hall

Plate XLI, figs. 7, 8

Orthoceras multiseptum Hall, Pal. New York, 2, 14, pl. 4 (bis), figs. 8a, b (1852).

Of the two specimens figured by Hall, the original of figure 8b is selected here as the type, since it appears to be a mature specimen. This is indicated by the small height of the uppermost camera. The diameter of this specimen at the base of the living chamber is 30 mm.; at a point 25 mm. farther down it is 28 mm., indicating an apical angle of about 5 degrees. The number of camerae in a length equal to the diameter of the conch is estimated at 9. The sutures of the septa are directly transverse. The concavity of the septa is estimated as equal to about the height of 2 camerae. No trace of the siphuncle remains.

Locality and Horizon.—*Orthoceras multiseptum* is described as coming from the upper fossiliferous part of the rock at Lockport, and as associated with *Pleurotomaria* at Medina. I suspect that the original of Hall's figure 8b came from Medina, although it is listed by Whitfield and Hovey as coming from the Medinan at Lockport, New York. The same fragment of rock which includes the original of figure 8b of *Orthoceras multiseptum*, includes also the original of figure 2b, described as *Modiolopsis? primigenius*, on the plate. It includes also numerous external and internal casts of the species described as *Pleurotomaria? pervetusta*. There is also part of a left valve of *Modiolopsis orthonota*. The horizon is regarded as equivalent to the Grimsby member of the Medinan.

Specimen No. 1437 B, in the American Museum of Natural History.

Lockport specimen.—The specimen figured by Hall on the same plate as 8a is compressed laterally. Its lateral diameter is 17 mm. at the base of the living chamber, decreasing to 15 mm. at a point 17 mm. farther down, indicating an apical angle of about

6.5 or 7 degrees. In a direction at right angles to the lateral diameter, at the base of the living chamber, the diameter is estimated at about 19 mm. The lateral compression of the conch may be due to pressure during fossilization. The number of camerae in a length of 19 mm. is estimated at 8. The sutures of the septa are directly transverse. Nothing is known regarding its siphuncle. This specimen is in the same fragment of rock as the original of figures 7a and 7b on Hall's plate 4 (bis).

Specimen No. 1437 A, in the American Museum of Natural History.

Orthoceras sp.—This specimen, represented by figures 7a and 7b on Hall's plate 4 (bis), consists of a living chamber of which a length of 20 mm. is preserved. The specimen is compressed obliquely in a direction which is more dorso-ventral than lateral. This compression probably was due to pressure during fossilization. Its greatest lateral diameter is 30 mm., its shortest lateral diameter is about 25 mm., at the base of the living chamber, and there is no definite change in dimensions within the short length of this chamber. Apparently there is a trace of a siphuncle, between 4 and 4.5 mm. in diameter, whose center is located almost 3 mm. from the ventral wall of the conch. It probably belongs to some orthoceroid conch, but, in reality, not enough remains to make even its generic relationship certain.

Specimen No. 1437 C, in the American Museum of Natural History.

28. *Orthoceras virgulatum* Hall

Plate XLV, fig. 5

Orthoceras virgulatum Hall, New York, 2, 96, pl. 29, figs. 2a, b, c (1852).

Specimen 93 mm. long, enlarging from a diameter of 4 mm. at its base to 8 mm. at its top, indicating an apical angle of 3 degrees. The living chamber is 26 mm. long, and the diameter at its base is about 6.75 mm. The second camera beneath the living chamber is 2 mm. in height, and that immediately above is slightly lower in height. The sutures of the septa are directly

transverse, and the concavity of the septa apparently equals nearly 2 mm., but this may be due to the state of fossilization of the single septum exposed, at the base of the uppermost camera. No trace of surface markings is preserved, and the shell may have been smooth.

The specimen described here is the original of Hall's figure 2c. It occurs in a very hard and very fine-grained sandstone, originally forming a layer about 35 mm. thick. The interior of the phragmacone, for almost its entire length, is occupied by white chert, except along its center. The upper part of the specimen is a sandstone cast of the interior of the living chamber and of the upper two camerae. No trace of the siphuncle remains.

Locality and Horizon.—Reynale's Basin, New York; in the Reynale's limestone member of the Lower Clinton.

No. 1576, American Museum of Natural History.

Remarks.—The original of figures 2a and 2b on the same plate has been lost. It was figured as 35 mm. long, 10 mm. in diameter at its top, the siphuncle being slightly excentric in location. The passage of this siphuncle through the septum at its base is about three-fourths of a millimeter in diameter.

The phragmacone described by Hall under the name *Oncoceras subrectum* is lost. Its generic affinities are uncertain. It was found in the lower cherty layers of the Clinton at Lockport, New York, and therefore also is to be assigned to the Reynale's member of the Clinton.

29. *Orthoceras clavatum* Hall

Plate XLV, fig. 6

Orthoceras clavatum Hall, Pal. New York, 2, 104, pl. 31, figs. 4a, b (1852).

Specimen 150 mm. in length, enlarging from a diameter of 20 mm. to one of 29 mm. in a length of 70 mm., indicating an apical angle of 7.5 degrees. At the top of the specimen, where its maximum lateral diameter is 29 mm., its minimum diameter at right angles to the latter is 20 mm. Its compression evidently is due to pressure during fossilization. The number of camerae in a

length equal to the maximum lateral diameter of the conch equals 10 along the upper half of the specimen, diminishing to 8.5 along the quarter directly beneath, and to 8 at the base of the specimen. Where the maximum diameter is 24 mm., the passage of the siphuncle through the septum is about 3 mm. in diameter, and its center is estimated to have been located 8 or 9 mm. from the ventral wall of the conch. Nothing is known about the form of its segments. The sutures of the septa slope downward from the dorsal toward the ventral side of the conch. Owing to the oblique lateral compression of this conch, the siphuncle is located a little toward one side of the present maximum lateral axis of the conch. In the present condition of the specimen, the sutures of the septa form an angle of 6 degrees with the horizontal plane. No surface ornamentation is preserved, and it is assumed that this surface was smooth.

Locality and Horizon.—South of Mohawk Village, in Herkimer county, New York, in the upper gray Herkimer sandstone of the Upper Clinton.

Specimen No. 1616 A, in the American Museum of Natural History.

Second specimen.—The original of figure 4b published by Hall consists of the living chamber with 5 camerae attached. Of the living chamber only a length of 22 mm. remains. The maximum lateral diameter at its base is 30 mm. Nearly 9 camerae occur in a length equal to this maximum diameter. The sutures of the septa, however, are not distinctly oblique, and even the genus of the specimen is in doubt.

Specimen No. 1616 B, in the American Museum of Natural History.

30. *Kionoceras subcancellatum* (Hall)

Plate XLV, fig. 7

Orthoceras cancellatum Hall, Pal. New York, 2, 292, pl. 63, figs. 4 a, b (1852).

Orthoceras subcancellatum Hall, in Miller, Amer. Pal. Foss. 1st ed., 245 (1877).

Conch slowly enlarging, as is evident from the parallelism of the extreme vertical ribs in the specimen here selected as the type. Of this specimen a width of 65 mm. remains, but its original width evidently was greater, possibly about 75 mm. The primary or most prominent vertical ridges are from 4.5 to 6 mm. apart, averaging 5 mm. The total number of primary ribs within the entire circumference of the conch equals at least 40, and may be nearer 50; but this can not be determined with exactness from the specimen at hand. These primary ribs are of slight elevation, and the spaces between them are flat, rather than concave. Along the median line of these flat spaces there usually is a single, distinctly less conspicuous secondary vertical rib. The flat spaces intervening between the primary and secondary vertical ribs are occupied by very fine and subequal vertical striae, from 6 to 9 in a width of 1 mm. The vertical ribs and striae are crossed by very fine transverse striae or wrinkles, about 4 or 5 in a length of 1 mm. These transverse striae are no more prominent than the vertical striae, though less numerous.

Locality and Horizon.—Lockport, New York, in the Rochester shale.

Specimen No. 1809 A, in the American Museum of Natural History.

31. *Kionoceras lockportense* Sp. nov.

Plate XLV, fig. 8

Orthoceras cancellatum Hall, Pal. New York, 2, 292, pl. 65, figs. 4a, b (1852).

Specimen with a maximum width of 27 mm., without any indication of its original diameter, which easily could have equalled twice this amount. The primary vertical ribs number 11 in a width of 24.5 mm., the interspaces therefore averaging 2.45 mm. in width. The median line of these interspaces is occupied by a single vertical rib, almost equal in prominence to the primary ribs. The flat spaces between the primary and vertical ribs are not occupied by numerous fine vertical striae, though an occasional vertical striation is seen. The surface of the conch is crossed also by equidistant transverse ridges, fully

as prominent as the vertical ribs, but not as narrow. These are almost as numerous as the primary and secondary vertical ribs together, numbering 17 in a length of 24.5 mm. In consequence, the surface of the shell is blocked off into quadrangular areas which are slightly taller than wide. In addition there are numerous sharply defined transverse striae, from 6 to 9 in a length of 1 mm.

Locality and Horizon.—Lockport, New York, in the Rochester shale.

Specimen No. 1809 B, in the American Museum of Natural History.

Remarks.—Compared with typical *Orthoceras subcancellatum* (Miller), the secondary ribs are much more prominent, vertical intermediate striae are nearly absent, the fine transverse striae are distinctly more numerous, and in addition there are the conspicuous equidistant ridges, which do not occur in that species.

32. *Dawsonoceras* sp. (Wolcott, New York)

Orthoceras annulatum ? Hall, Pal. New York, 2, 96, pl. 29, fig. 3 (1852).

Specimen 72 mm. long. The upper part, 17 mm. long, consists of a trace of an impression on the exterior of the shell showing transverse scalloped striae, similar to those of *Dawsonoceras americanum* Foord. Between 17 and 31 mm. beneath the top of the specimen 6 annulations of the conch are so poorly exposed that the diameter of the latter can not be determined with exactness. Between 31 and 36 mm. beneath the top there is a diagonal series consisting of 3 segments of the siphuncle, the middle one of which is 1.7 mm. long and 1.4 mm. wide. The segment directly beneath this series is missing. Then follows a series of 5 segments with a total length of 8 mm., of which the uppermost segment is 1.75 mm. long and 1.2 mm. in diameter. Traces of annulations and of scalloped striae occur along one side of these 5 segments. Between 48 and 62 mm. beneath the top of the specimen there are 10 segments of the siphuncle; the lowest of these is 1.1 mm. long

and 1 mm. wide. Between 62 and 72 mm. there are 9 segments, of which the lowest is 1 mm. long and about 0.7 mm. wide.

Locality and Horizon.—From the shale below the ore beds at Wolcott, in Wayne county, New York; in the Clinton. A fragment of *Pterinea emacerata* occurs in the same piece of rock. Listed by Chadwick from the Bear Creek shale, beneath the Furnaceville Iron Ore. In his earlier writings, however, Hall put these fossiliferous shales *above* the ore, so that there is a possibility, according to both Chadwick and Hartnagel, of the *Dawsonoceras* being of lower Reynales limestone age.

No. 1577, American Museum of Natural History.

Remarks.—This specimen is too poorly preserved to be identified with certainty as *Dawsonoceras americanum*, but its generic identity is unquestioned.

33. *Rizoceras lockportense* Sp. nov.

Plate XLI, figs. 9 A, B

Specimen regularly enlarging from a maximum diameter of 11 mm. near the base of 20 mm. at the aperture, at 18 mm. farther up, indicating an apical angle of about 30 degrees. The shorter diameter at the aperture equals 18 mm., but it is not known whether this shorter diameter was natural to the species or whether it is due to compression. The living chamber is 14 mm. in height at one end of the larger diameter of the conch, and a height of 11.5 mm. is preserved at the other end, but it is not known whether this difference in height was natural, or whether it is due to difference in the length of the part retained by the specimen. At its base, 4 camerae are preserved, occupying a total height of 5 mm. The sutures are directly transverse, and straight. The location of the siphuncle is unknown. The surface of the shell was smooth.

Locality and Horizon.—Lockport, New York, from the Medina sandstone, in the same tray with the type of *Oncoceras gibbosum* Hall, and apparently from the same horizon.

Specimen No. 1438B, in the American Museum of Natural History.

34. *Lechritrochoceras notum* (Hall)

Plate XL, figs. 8 A, B

Trochoceras notum Hall, 20th Rep. New York State Cab. Nat. Hist., 360, pl. 16, figs. 1, 2 (1868).

The type specimen consists of the greater part of a living chamber, the part near the aperture being missing. The lengthwise curvature of the ventral side of this chamber has a radius of about 21 mm. The maximum diameter of the complete conch, across the umbilical opening, is estimated to have been approximately 35 mm. The dorsal side of the living chamber is impressed along its former line of contact with the more apical part of the conch, and this impression is distinctly above the median line of the dorsal side, but not enough to bring the apical end of the conch up to a level with the upper margin of the living chamber, when the conch lies on that one of its lateral sides which is more distant from its apical end. In that position, moreover, the lengthwise curvature of the conch is dextral. At the base of the living chamber the dorso-ventral diameter of the conch is 14 mm., and the lateral diameter is estimated at 17 mm. The passage of the siphuncle through the septum is 1.3 mm. in diameter, and its center is located 6 mm. from the ventral side of the conch. The suture of the septum is nearly straight or only slightly concave across the lateral sides of the conch. The concavity of the septum is 4 mm. The transverse annulations number 5 in a length of 16 mm. when this distance is measured along the median part of the ventral side of the living chamber. Along the lateral sides they curve strongly backward or downward from the dorsal side as far as the ventro-lateral shoulders, and then increasingly downward as far as the median line of the ventral side. They are most distinct ventrally and ventro-laterally. No trace of surface ornamentation, in addition to the transverse rib-like annulations, remains.

Locality and Horizon.—From Bridgeport, Illinois; in the Racine dolomite.

Specimen No. 2127-2, in the American Museum of Natural History.

Remarks.—*Trochoceras notum* is distinguishable from *Trochoceras costatum* by the much smaller size of the complete conch. Moreover, in the type of *Trochoceras notum* the transverse annulations remain distinct laterally until within a short distance of the margin of the aperture; while in *Trochoceras costatum* these annulations become less distinct and more numerous along the upper half of the living chamber. In *Trochoceras notum*, as in *Trochoceras desplainense*, the uppermost annulation, just before reaching the aperture, tends to disappear or is entirely obsolete.

Specimens with annulations faint ventrally.—In some living chambers the annulations are distinct laterally as far as the ventro-lateral shoulders, but become rapidly faint ventrally, and may be almost obsolete along the median part of the ventral side of casts of the interior of these chambers. In the Walker Museum at Chicago University one specimen, from Bridgeport, Illinois, is numbered 18097c; another, from Hawthorne, Illinois, is numbered 21883C.

Two similar specimens, but with 7 annulations in a length of 18 mm., measured along the ventral side of the living chamber, from Bridgeport, Illinois, are numbered 21883A, B. That the faintness of the annulations ventrally is not a specific difference is shown by a specimen collected by the writer west of Chicago, with equally numerous annulations, but with these annulations fully as distinct ventrally as dorsally.

35. *Armenoceras vertebratum* (Hall)

Plate XLI, figs. 1-6

Ormoceras vertebratum Hall, Pal. New York, 2, 94, pl. 29, figs. 1a-g (1852).

Selected type.—The original of Hall's figure 1f here is selected as the type of the species, since, among the specimens figured by Hall, it shows its structure best. The diameter of this specimen at its upper end is estimated at 40 mm., and its apical angle appears to be approximately 5 degrees, though this cannot be determined with exactness. About 7 camerae occur in a length equal to the diameter of the conch at the top of the series of

camerae counted. The exact direction of the sutures of the septa can not be determined, but it is assumed to be directly transverse. The concavity of the septa equals about the height of one of the camerae. The siphuncle is either central in its location or is only slightly excentric. At the top of the specimen 4 segments of the siphuncle occupy a total vertical length of 24 mm.; at its base 4 segments have a total vertical length of 22 mm; but along the entire length of the specimen the maximum lateral diameter of these segments within the camerae is practically uniform, equalling about 11.5 mm. Consecutive segments meet at an acute angle, there being no intervening short septal necks, as in typical *Ormoceras*.

As in other actinoceroids, the inner walls of the siphuncle are lined with calcareous deposits, which are thickest around the inner margin of the septa, at the so-called septal necks, embracing the latter in lunate form, when seen in vertical sections through the center of the siphuncle. The central part of the siphuncle, originally free from calcareous deposits, is now filled with a hard limestone matrix, darker in color than the deposits lining the inner walls of the siphuncle. This darker limestone deposit along the center of the siphuncle enlarges within each camera, the attenuated and more or less horizontally laminar margins of these enlargements separating the successive lunar deposits mentioned previously, at mid-height of the camerae. The upper half of the camerae, exterior to the segments of the siphuncle, is occupied by limestone matrix similar to that filling the central part of the siphuncle. The original structure within these camerae probably was that frequently described as pseudo-septal. Specimen 1581F.

The original of Hall's figure 1*d* does not retain at present the 3 segments of the siphuncle which were figured as free from the surrounding camerae. The diameter of this specimen may have been from 42 to 44 mm., that of the segments of the siphuncle equalling 11.5 mm. Five segments of the siphuncle occupy a length of 40 mm. Specimen 1581D.

An unfigured specimen from the Hall collection, evidently from the same thin limestone layer as the preceding specimen, was

about 42 mm. in diameter, with segments of the siphuncle 12 mm. in diameter, 6 segments occurring in a length of 40 mm. Pseudo-septa within the camerae are indicated indistinctly. This specimen is numbered 1581B.

The original of Hall's figure 1c does not greatly resemble the published figure except in size and in the number of camerae. The original diameter of this specimen probably was about 44 mm.; in that case the location of the siphuncle was moderately eccentric. The diameter of the siphuncle is 12.5 mm., and 6 camerae occupy a length of 42 mm. Specimen No. 1581C.

The original of Hall's figure 1e is 105 mm. in length. The top of the specimen, for a length of 20 mm., consists of the so-called endosiphuncle, or the matrix filling the cavity left in the central part of the siphuncle by the calcareous deposits lining the inner walls of its segments; this endosiphuncle presents acutely angular annulations a little above mid-height within the camerae. Below this level, 12 segments occupy a length of almost 50 mm., the upper 3 segments having a total length of 16 mm., the lower segments being more crowded. Below this level 4 segments of the siphuncle, occupying a total length of 19 mm., have weathered so as to expose the lower part of the endosiphuncle, beneath which there is another camera, but without a distinct indication of the siphuncle. The diameter of the conch at the top of the specimen is estimated at 42 mm. The corresponding diameter of the siphuncle appears to be 12.5 mm. At a point 55 mm. farther down the diameter of the conch is about 38 mm., suggesting an apical angle of about 5 degrees, though this can not be determined with exactness from the specimen at hand. Specimen 1581E.

The original of Hall's figures 1a, 1b is cut vertically neither through the center of the conch nor through the center of the siphuncle. The diameter of the conch at the top of the specimen is estimated at 39 mm., and its apical angle appears to have been 9 degrees, which is much larger than indicated by the specimens described previously; but the latter are far less suitable for the determination of this angle. Only 5 camerae occur in a length of 38 mm., which is a smaller number than presented by

the specimen described first. The sutures of the septa rise at an angle of about 14 degrees toward the ventral side of the specimen. There is no means of determining whether this rise is normal or is due to oblique compression of the conch during fossilization. The siphuncle appears to be distinctly excentric in its location. Where the height of the segments of the siphuncle is 8 mm., the lateral diameter appears to be about 11 mm. This contrasts strongly with the specimen described first, in which the corresponding dimensions are 6 and 11.5 mm. Finally the point of contact between successive segments of the siphuncle, in vertical sections, is less acutely angular. Nevertheless, there is a possibility of this specimen belonging to the same species as the preceding. Specimen No. 1581A.

Locality and Horizon.—Reynale's Basin, in Wayne county, New York; from the Reynale's limestone, in the lower part of the Clinton.

No. 1581, American Museum of Natural History.

Remarks.—Specimens B and C are associated in the same rock with *Hyattidina congesta* (Conrad), and specimen D evidently is from the same thin limestone layer as specimen B. Specimen F may have come from the same granular limestone layer as specimen C. This may have been the origin also of specimen A, although this is less certain. Specimen E came from a granular limestone layer which is less coarse than that including specimen C, but differs from the latter in being lighter in color and in not including the *Hyattidina congesta*.

36. *Amphicyrtoceras abruptum* (Hall)

Plate XLVI, figs. 6 A, B

Orthoceras? abruptum Hall, Pal. New York, 2, 97, pl. 29, figs. 4a, b (1852).

Specimen consisting of the lower part of the living chamber with 5 camerae still attached. Of these the uppermost camera presents a height of 3 mm. along the ventral side of the conch, contrasting strongly with the height of 6 mm. presented by each of the two immediately underlying camerae. The conch is

strongly depressed dorsoventrally, the lateral diameter being 42 mm., and the dorso-ventral one 35 mm. at the base of the living chamber, the corresponding dimensions at the base of the specimen, 28 mm. farther down, being 33 and 25 mm., indicating an apical angle of about 19 degrees in a lateral direction. The dorsal side, in the small length preserved, presents an almost straight outline; the ventral outline is slightly convex. The sutures of the septa are almost straight, but diverge moderately from the dorsal toward the ventral side of the conch. The concavity of the septa equals about the height of one of the camerae. The passage of the siphuncle through the septum at the base of the specimen is about 3 mm. in diameter, and its center is located about 3 mm. from the ventral wall of the conch.

Locality and Horizon.—This specimen was sent to Hall by Col. Jewett, of Lockport, New York, as coming from the upper limestone in the Clinton of that place, but for some unknown reason is referred by Whitfield and Hovey to some part of the Clinton at Reynale's Basin. It is doubtfully listed by Chadwick from the Irondequoit, but, in a letter to the writer, he recognizes the possibility of its being of Gasport age.

Specimen No. 1578, in the American Museum of Natural History.

Remarks.—The specimen belongs to the same group as *Amphicyrtoceras orcas* (Hall), and *Amph. laterale* (Hall), from the Racine of Wisconsin and Illinois. In the Lockport, at Grimsby, Ontario, this genus is represented by the two species originally described as *Oncoceras petitti* Billings and *Oncoceras thales* Billings. Dr. M. Y. Williams figured another specimen of this genus from the lower Guelph at Wiarton, Ontario, under the name *Poterioceras* n. sp., in his Silurian Geology and Faunas of Ontario Peninsula, and Manitoulin and Adjacent Islands.

Among these, *Amphicyrtoceras abruptum* resembles the species originally described as *Oncoceras thales* ventrally, but the latter is more curved lengthwise, both along the convex ventral and the concave dorsal side. The species originally described as *Oncoceras petitti* enlarges more rapidly along the phragmacone, and is more strongly curved lengthwise along its ventral side. The

species figured by Williams under *Poterioceras* is larger in size, and less compressed dorso-ventrally.

Not enough is known of the living chamber of *Amphicyrtoceras abruptum* to make it a well defined species.

37. *Amphicyrtoceras* sp. (Niagara Falls—1)

Plate XLVI, fig. 2

Gomphoceras?, Hall, Pal. New York, 2, 290, pl. 61, fig. 1a (1852).

Specimen 53 mm. long, exposing its ventral side. The conch reaches its maximum diameter at the base of the living chamber where it attains a width of 26 mm., diminishing to 19 mm. at the aperture, 20 mm. farther up. The rate of enlargement of the phragmacone is approximately the same as the rate of decrease in diameter of the living chamber. Along the lower part of the living chamber and the upper part of the phragmacone the lengthwise ventral outline has a curvature with a radius of about 30 mm. The left margin of the specimen suggests that the dorsal outline was distinctly gibbous along the parts of the living chamber and phragmacone just mentioned, but tended to be concave along the lower part of the phragmacone. The surface of the shell is marked by low broad transverse lines or bands, of which 6 or 7 occur in a length of 5 mm. Along the median line of the ventral side, they curve gently downward, forming a hyponomic sinus of about 1 mm. in depth.

Locality and Horizon.—In a fragment of limestone below the cliffs at Niagara Falls, associated in the same fragment of rock with *Goldius niagarensis* (Hall). From the Lockport formation.

No. 1833, American Museum of Natural History.

Remarks.—The specimen here described evidently is from the same horizon as the specimen of *Amphicyrtoceras* figured by Hall under 2b and 2c on the same plate. Compared with the latter, the specimen here under consideration is less curved lengthwise, and diminishes more strongly toward the aperture. Compared with *Amphicyrtoceras sauridens* (Clarke and Ruedeman), the living chamber of the specimen here described is longer, and contracts more evenly.

38. *Amphicyrtoceras* sp. (Lockport)

Plate XLVI, fig. 4

Gomphoceras?, Hall, Pal. New York, 2, 290, pl. 61, fig. 1b, 1852.

This specimen probably also is an *Amphicyrtoceras*. Apparently it exposes the ventral side of the conch, but the specimen was squeezed almost flat before fossilization, and the location of the ventral sinus at its various stages of growth can not be determined. It evidently is a distinct species from the preceding specimen. The living chamber is much shorter, and the transverse markings consist of much finer and more numerous raised lines, about 16 in a length of 5 mm. The general aspect of the specimen apparently was similar to that of *Amphicyrtoceras futile* (Billings), from east of Jupiter River, on Anticosti, in the Jupiter formation.

Locality and Horizon.—Lockport, New York; from the Rochester shale.

No. 1832, American Museum of Natural History.

39. *Amphicyrtoceras subcancellatum* (Hall)

Plate XLVI, fig. 1

Cyrtoceras? cancellatum Hall (preoccupied), Pal. New York, 2, 290, pl. 61, fig. 2a (not figs. 2b, c) (1852).*Cyrtoceras subcancellatum* Hall, in Miller, North Amer. Geol. Pal., 1st. ed., 243 (1877).

Selected type.—Of the two specimens figured by Hall, only the original of his figure 2a presents the vertical markings, which, together with the horizontal striae, produce the cancellated appearance. Hence this specimen here is selected as the type of the species. However, Hall's figure is a little misleading, since the artist found it impossible to delineate the vertical markings without making them more distinct than they are in the original specimen. In general, both the transverse and the vertical markings are quite indistinct, except locally, where they are fully as distinct as they are represented by Hall's artist over the entire surface of the specimen. Near the base of the specimen, for

instance, 5.5 to 7 well defined transverse markings occur in a length of 5 mm.; near its top, 7 narrow transverse striae occur within the same length. At most intermediate points the transverse striae are very fine, often very numerous, but very faint, and difficult to count. The vertical markings are very low and flat, and number 5 or 6 in a width of 5 mm. They are best defined in the casts of the interior of the conch, but are faintly visible also on the exterior of the shell. Similar vertical markings appear also on some specimens of *Amphicyrtoceras orcas*, and, judging from that species, the presence or absence of these vertical markings is characteristic of certain individuals, rather than of all members of the species. On the ventral side of the conch, the transverse striae curve gently downward, forming a shallow hyponomic sinus along its median line, the sides of this sinus diverging at an angle of 160 degrees.

The specimen is crushed flat laterally. In its present condition it enlarges from a dorso-ventral diameter of 30 mm. near its base to about 45 mm. at its top, in a height of 85 mm. measured along the ventral outline of the conch. The original dorso-ventral diameter evidently was considerably less. The original length of the living chamber, measured along the ventral side of the conch, probably was about 50 mm. In the present condition of the specimen its dorsal outline is approximately straight along the lower three-fourths of the living chamber, curving outward for a length of 10 mm. at its top. Originally the lower two-thirds of the living chamber may have been slightly convex in vertical outline, as in typical *Amphicyrtoceras*. In the present condition of the specimen, its ventral outline presents a convex curvature with a radius of approximately 66 mm. Possibly the phragmacone presented a corresponding concave dorsal outline, except in the immediate vicinity of the living chamber.

Locality and Horizon.—Lockport, New York, in the Rochester shale.

Specimen No. 1831-1, in the American Museum of Natural History.

Remarks.—If not a typical *Amphicyrtoceras*, the specimen here selected as the type of *Cyrtoceras? subcancellatum* Hall may be

related generically to the species described by Clarke and Ruedemann as *Cyrtoceras bovinum*. However, the distinct, though shallow, hyponomic sinus suggests *Amphicyrtoceras*.

40. *Amphicyrtoceras* sp. (Niagara Falls—2)

Plate XLVI, figs. 3 A, B

Cyrtoceras? subcancellatum Hall, Pal. New York, 2, 290, pl. 61, Figs. 2b, c(not 2a) (1852).

Specimen about 77 mm. in length, measured along its ventral outline, and 62 mm. in length when measured along its dorsal outline. The ventral outline has a convexity with a radius of about 47 mm.; the dorsal outline has a concavity with about the same radius, but between 14 and 37 mm. beneath the margin of aperture this dorsal outline is faintly convex, the convexity being less than 1 mm. The base of the living chamber is estimated at 29 mm. beneath the margin of the aperture on the dorsal side of the conch. At the base of the specimen, its lateral diameter is estimated at 28 mm., and the dorso-ventral diameter at 23 mm. The corresponding dimensions at the maximum lateral diameter of the conch, at the base of the living chamber, are about 38 and 32 mm. At the aperture, the corresponding diameters are estimated at 32 and 27 mm. The maximum dorso-ventral diameter, at about one-fourth of the height of the living chamber above its base, is about 34 mm. All of these dimensions are subject to revision when an undistorted specimen is found, but they probably do not stray far from their original lengths.

The surface of the shell is crossed by relatively low transverse lines of growth, which curve slightly downward along the ventral side of the conch, and form a shallow hyponomic sinus along its median line. The sides of the sinus diverge at an angle of about 11 degrees.

Locality and Horizon.—From a fragment of limestone below the cliff at Niagara Falls, New York; in the Lockport limestone. *Goldius niagarensis* (Hall) is associated with the species of *Amphicyrtoceras* here described in the same rock fragment.

Specimen No. 1831-2, in the American Museum of Natural History.

Remarks.—Clarke and Ruedemann described *Amphicyrtoceras sauridens* from the Lower Shelby bed within the Lockport dolomite at Rochester, New York. However, this is a much smaller species, with a more rapidly enlarging phragmacone. Compared with *Amphicyrtoceras thales* Billings, from the Lockport at Grimsby, Ontario, the Niagara Falls species is more slender. Compared with *Amphicyrtoceras petitti* Billings, from the same horizon and locality, the Niagara Falls species enlarges less rapidly, and is more slender.

41. *Gomphoceras* (?) *gibbosum* (Hall)

Plate XLVI, figs. 7 A, B

Oncoceras gibbosum Hall, Pal. New York, 2, 13, pl. 4 (bis), figs. 6 A, B, C (1852).

Specimen 35 mm. in length along its ventral side, 30 mm. long dorsally and also along the median part of its lateral sides. The margin of the aperture curves gently downward along its lateral sides, rising more strongly ventrally than dorsally. The height of the living chamber is 14 mm. dorsally, but increases to 15.5 mm. ventrally. In a corresponding manner, the total height of the 8 camerae is 16 mm. along the dorsal side of the conch, but 20.5 mm. ventrally. These measurements suggest that the central axis of the conch may have been slightly curved lengthwise, though that part of the specimen which remains apparently is straight, and its ventral and dorsal vertical outlines apparently are almost equally convex. The conch is compressed laterally, its dorso-ventral diameter at the base of the living chamber being 26.5 mm., its lateral one being estimated at 23 or 24 mm. At the aperture the corresponding diameters are 24 mm. and 21.5 mm. The specimen is a cast of the interior of the conch. Along the upper part of this conch, for a length of 6 mm. from the aperture, the interior of the wall of the living chamber evidently was thickened, a corresponding constriction occurring on the cast itself. It is estimated that eleven camerae occurred in a length equal to the maximum

diameter of the conch. The sutures of the septa are straight along the lower part of the specimen, but rise ventrally along the upper part of the phragmacone. The concavity of the septa scarcely equals the height of one camera. The siphuncle is located close to the ventral wall of the conch, its center being about 2 mm. distant. Its diameter at its passage through the lowest septum is 2 mm. Nothing is known of the form of its segments.

Locality and Horizon.—Lockport, New York, from near the upper part of the Medina sandstone.

No. 1438A, American Museum of Natural History.

Remarks.—This specimen probably does not belong to the genus *Gomphoceras*, although it has some resemblance in general outline. The distinct downward curvature of the sutures of the septa along the lateral sides of the conch near the top of the phragmacone, is opposed to such a correlation. Moreover, it is not known that the segments of the siphuncle are nummuloidal. The specimen probably belongs to an unnamed genus, but not enough is known of its structure to warrant its use as a genotype.

PLATE II

PLATES

PLATE XL

Fig. 1. *Cycloceras undulostriatum* (Hall). Lateral views; of these A is the original of Hall's figures 7a, b, c, on his plate 43; B is the original of his figs. 7d, f, h; C, of his fig. 7e; and D, of his figs. 7i, k. Middleville, New York; in the lower shaly layers of the Trenton. No. 804, American Museum of Natural History.

Fig. 2. *Deirotrochoceras distans* (Hall). Vertical section in a lateral direction through the siphuncle. Turin, Lewis county, New York; in the upper part of the Trenton limestone. No. 800, American Museum of Natural History.

Fig. 3. *Spyroceras middlevillense* Foerste. A, lateral view; B, same, enlarged 2.5 diameters. Middleville, New York; from the lower shaly layers of the Trenton. No. 805-1, American Museum of Natural History.

Fig. 4. *Spyroceras anellus* (Conrad). Lateral view. Mineral Point, Wisconsin; in the Beloit member of the Black River formation. No. 805-3, American Museum of Natural History.

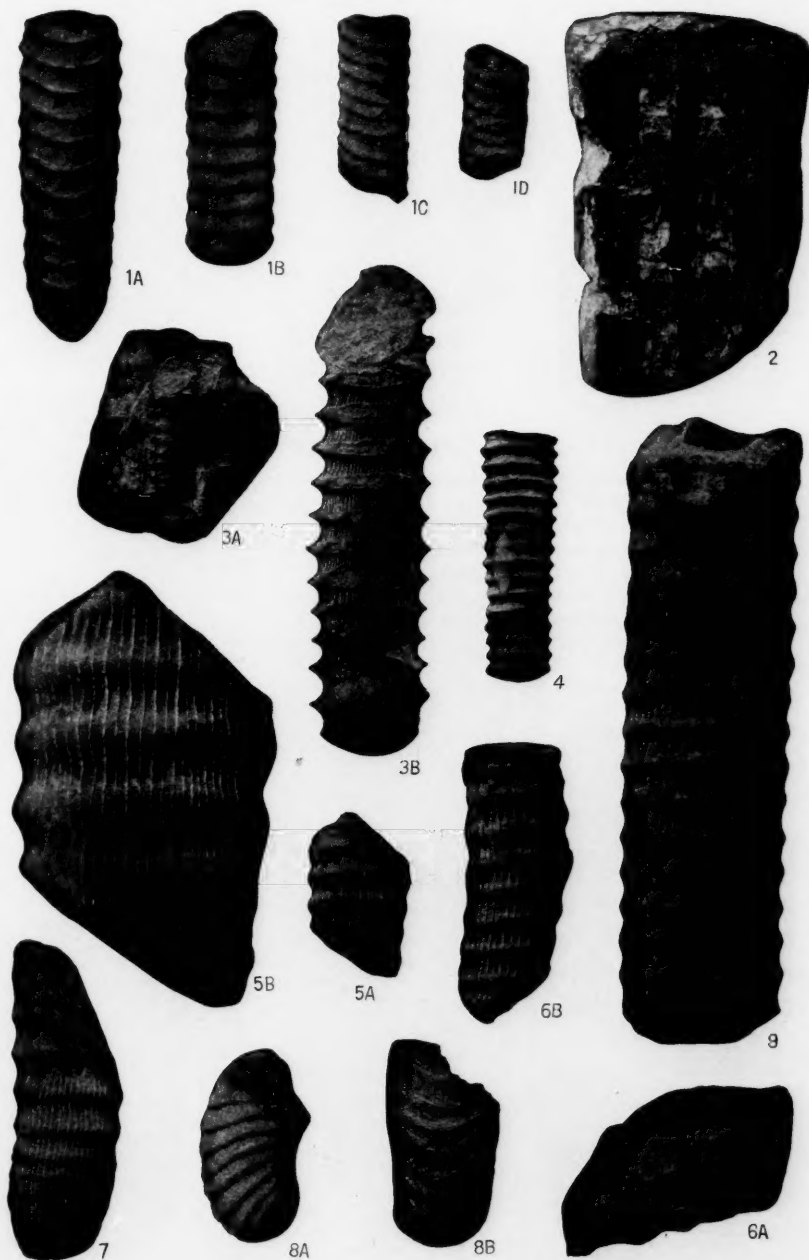
Fig. 5. *Spyroceras bilineatum* (Hall). A, lateral view; B, same, magnified 2.5 diameters. Middleville, New York, in the lower shaly part of the Trenton. No. 808-1, American Museum of Natural History.

Fig. 6. *Spyroceras clathratum* (Hall). A, lateral view; B, same, magnified about 2.5 diameters. Middleville, New York; in the lower shaly limestone of the Trenton. No. 806, American Museum of Natural History.

Fig. 7. *Orthoceras bilineatum* var. *alpha* (Hall). Lateral view. Middleville, New York, in the lower shaly strata of the Trenton. No. 808, American Museum of Natural History.

Fig. 8. *Lechritrochoceras notum* (Hall). A, lateral view; B, ventral view. Bridgeport (Chicago), Illinois; in the Racine dolomite. No. 2127-2, American Museum of Natural History.

Fig. 9. *Spyroceras olorus* (Hall). Lateral view. Middleville, New York; in the compact limestone of the Trenton. No. 803, American Museum of Natural History.



AUG. F. FOERSTE

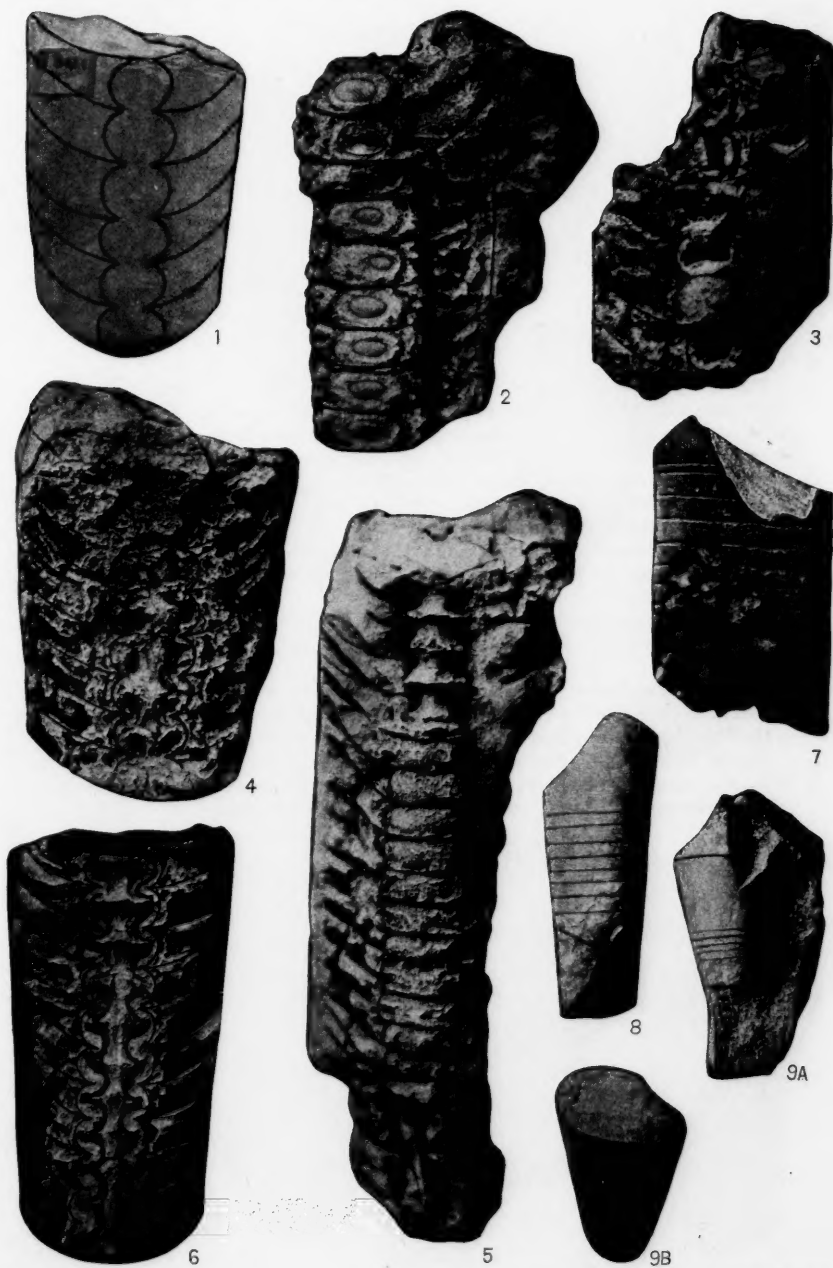
ORDOVICIAN AND SILURIAN CEPHALOPODS

PLATE XLI

Figs. 1-6. *Armenoceras vertebratum* (Hall). 1, vertical section, but not through center of siphuncle. 2-6, weathered specimens exposing the siphuncle; of these, fig. 6 shows the structure of the siphuncle best. Reynale's Basin, Wayne county, New York; in the Reynale's limestone member of the Lower Clinton. No. 1581, American Museum of Natural History.

Figs. 7, 8. *Orthoceras multiseptum* Hall. 7, lateral view, with base of living chamber at top; 8, possibly a younger specimen. Lockport, New York; in the Grimsby member of the Medinan. No. 1437, American Museum of Natural History.

Fig. 9. *Rizoceras lockportense* Foerste. A, viewed from narrower side; B, from broader side. Lockport, New York; from near the upper part of the Medinan sandstone. No. 1438-B, American Museum of Natural History.



AUG. F. FOERSTE

ORDOVICIAN AND SILURIAN CEPHALOPODS

PLATE XLII

Fig. 1. *Cyrtorizoceras constrictostriatum* (Hall). A, B, lateral views of the same specimen; C, ventral view, showing the surface striae and three camerae, enlarged 2 diameters. Middleville, New York; in the lower shaly layers of the Trenton. No. 818, American Museum of Natural History.

Fig. 2. *Cyrtorizoceras constrictostriatum* (Hall). A, lateral view; B, ventral view. Middleville, New York; in the lower shaly members of the Trenton. No. 818, American Museum of Natural History.

Fig. 3. *Cyrtorizoceras filosum* (Conrad). Lateral view. Watertown, New York; in the higher crystalline part of the Trenton as exposed there. No. 817, American Museum of Natural History.

Fig. 4. *Cyrtorizoceras camurum* (Hall). Lateral view. Middleville, New York; in the lower shaly strata of the Trenton. No. 816, American Museum of Natural History.

Fig. 5. *Cyrtorizoceras whitneyi* (Hall). A, lateral view; B, ventral view. Maquoketa creek, 12 miles northwest of Dubuque, Iowa; in the Maquoketa phase of the Richmond. No. 1400, American Museum of Natural History.

Fig. 6. *Cyrtorizoceras whitneyi* (Hall). A, lateral view; B, ventral view. Maquoketa creek, 12 miles northwest of Dubuque, Iowa; in the Maquoketa phase of the Richmond. No. 1400, American Museum of Natural History.



PLATE XLIII

Fig. 1. *Zitteloceras percurvatum* Foerste. A, ventral view; B, lateral view, indicating both the transverse striae and some of the sutures of the septa; C, oblique lateral view, showing course of the transverse striae, only the alternating larger ones being shown farther up, while both larger and smaller ones are exposed farther down, magnified 2 diameters. Mineral Point, Wisconsin; in the Platteville member of the Black River. No. 995, American Museum of Natural History.

Fig. 2. *Zitteloceras beloitense* Foerste. A, ventral view; C, lateral view; B, same, touched up to indicate the course of the transverse striae; D, touched up, to indicate the course of the sutures of the septa. Beloit, Wisconsin; from the Platteville member of the Black River. No. 992, American Museum of Natural History.

Fig. 3. *Zitteloceras hallianum* (D'Orbigny). A, lateral view; B, ventral view, enlarged 2.5 diameters. Middleville, New York; in the lower part of the Trenton. No. 823, American Museum of Natural History.

Fig. 4. *Zitteloceras* (?) *tenuistriatum* (Hall). A, lateral view; B, ventral view, enlarged about 1.9 diameters. Mineral Point, Wisconsin; in the Platteville member of the Black River. No. 995, American Museum of Natural History.

Fig. 5. *Manitoulinoceras middlevillense* Foerste. A, lateral view, with transverse striae; B, same, with course of sutures of septa indicated; C, ventral view, showing both coarser and finer transverse striae, magnified 1.9 diameters. Middleville, New York; in the lower part of the Trenton. No. 822-2, American Museum of Natural History.

Fig. 6. *Cyrtorizoceras* sp. Lateral view. Carlisle, Pennsylvania; in the Trenton. No. 822-1, American Museum of Natural History.



AUG. F. FOERSTE

ORDOVICIAN AND SILURIAN CEPHALOPODS

PLATE XLIV

Fig. 1. *Conradoceras macrostomum* (Hall). A, dorsal view; B, lateral view; C, ventral view showing the siphuncle. Mineral Point, Wisconsin; in the Platteville member of the Black River. No. 822-3, American Museum of Natural History.

Fig. 2. *Diestoceras alceum* (Hall). A, ventral view, showing cavity left by siphuncle; B, lateral view with ventral side on left. Beloit, Wisconsin; in the Platteville member of the Black River. No. 1000, American Museum of Natural History.

Fig. 3. *Ephippiorthoceras subarcuatum* (D'Orbigny). A, lateral view; B, same, showing only the larger conch, regarded as the type. Middleville, New York; in the lower shaly part of the Trenton. No. 819, American Museum of Natural History.



AUG. F. FOERSTE

ORDOVICIAN AND SILURIAN CEPHALOPODS

PLATE XLV

Fig. 1. *Oncoceras* cf. *abruptum* Hall. A, lateral view; B, ventral view with glimpses of the siphuncle. Beloit, Wisconsin; in the Platteville member of the Black River. No. 997, American Museum of Natural History.

Fig. 2. *Oncoceras abruptum* Hall. A, ventral view; B, lateral view. Platteville, Wisconsin; in the Platteville member of the Black River. No. 997-2, American Museum of Natural History.

Fig. 3. *Manitoulinoceras neleum* (Hall). A, lateral view; B, dorsal view; C, ventral view. Platteville, Wisconsin; from the Platteville member of the Black River No. 992-2, American Museum of Natural History.

Fig. 4. *Cyrtorizoceras multicameratum* (Hall). A, lateral view; B, ventral view. Middleville, New York; in the lower shaly part of the Trenton. No. 820, American Museum of Natural History.

Fig. 5. *Orthoceras virgulatum* Hall. Lateral view, exposing the siphuncle. Reynale's Basin, New York; in the Reynale's limestone member of the Lower Clinton. No. 1576, American Museum of Natural History.

Fig. 6. *Orthoceras clavatum* Hall. Lateral view. South of Mohawk Village, in Herkimer county, New York; in the Herkimer sandstone member of the Upper Clinton. No. 1616, American Museum of Natural History.

Fig. 7. *Kionoceras subcancellatum* (Hall). Surface of fragment. Lockport, New York; in Rochester shale. No. 1809A, American Museum of Natural History.

Fig. 8. *Kionoceras lockportense* Foerste. Surface of a small fragment. Lockport, New York; in the Rochester shale. No. 1809B, American Museum of Natural History.



AUG. F. FOERSTE

ORDOVICIAN AND SILURIAN CEPHALOPODS

PLATE XLVI

Fig. 1. *Amphicyrtoceras subcancellatum* Hall. Lateral view. Lockport, New York; in the Rochester shale. No. 1831-1, American Museum of Natural History.

Fig. 2. *Amphicyrtoceras* sp. Ventral view. Niagara Falls, New York; from the Lockport formation. No. 1833, American Museum of Natural History.

Fig. 3. *Amphicyrtoceras* sp. A, lateral view; B, ventral view. Niagara Falls, New York; in the Lockport limestone. No. 1831-2, American Museum of Natural History.

Fig. 4. *Amphicyrtoceras* sp. Probably the ventral view. Lockport, New York; from the Rochester shale. No. 1832, American Museum of Natural History.

Fig. 5. *Orthoceras* sp. A, oblique lateral view; B, septum at base of living chamber. Lockport, New York; in the Grimsby member of the Medinan. No. 1437C, American Museum of Natural History. See under *Orthoceras multiseptum*.

Fig. 6. *Amphicyrtoceras abruptum* (Hall). A, ventral view; B, lateral view. Reynale' Basin, New York; either of Irondequoit or Gasport age. No. 1578, American Museum of Natural History.

Fig. 7. *Gomphoceras gibbosum* (Hall). A, lateral view; B, cross-section at base of specimen. Lockport, New York; near the upper part of the Medinan. No. 1438A, American Museum of Natural History.



AUG. F. FOERSTE

ORDOVICIAN AND SILURIAN CEPHALOPODS

PLATE XLVII

Fig. 1. *Ulrichoceras beloitense* sp. nov. A, dorsal view; B, lateral view with dorsal side on left; C, ventral view. Beloit, Wisconsin; presumably from the Beloit member of the Black River. No. 25302, U. S. National Museum.

Fig. 2. *Cyrtorizoceras filiosum* (Conrad). A, cross-section at top of conch; B, lateral outline with apical end restored; C, ventral side with outline of hyponomic sinus indicated by course of transverse striae. See also pl. XLII, fig. 3.

Fig. 3. *Cyrtorizoceras constrictostriatum* (Hall). A, cross-section at top of third camera above base; B, ventral side with outline of hyponomic sinus indicated by course of transverse striae. See also pl. XLII, fig. 1.

Fig. 4. *Cyrtorizoceras constrictostriatum* (Hall). Cross-section at base of living chamber. See also pl. XLII, fig. 2.

Fig. 5. *Cyrtorizoceras camurum* (Hall). Cross-section at base of living chamber. See also pl. XLII, fig. 4.

Fig. 6. *Ephippiorthoceras subarcuatum* (D'Orbigny). Cross-section at base of living chamber. See also pl. XLIV, fig. 3.

Fig. 7. *Cyrtorizoceras multicameratum* (Hall). Cross-section of specimen at base of living chamber. See also pl. XLV, fig. 4.

Fig. 8. *Centrocyrtoceras subannulatum* (D'Orbigny). Cross-section at top of specimen represented in Jour. Sci. Lab. Denison Univ., 21, pl. XLV, fig. 4A, (1926).

Fig. 9. *Cyrtorizoceras* sp. (Carlisle, Pa.). Cross-section at base of specimen. See also pl. XLIII, fig. 6.

Fig. 10. *Zitteloceras beloitense* Foerste. Cross-section of conch. See also pl. XLIII, fig. 2.

Fig. 11. *Conradoceras macrostomum* (Hall). A, cross-section at base of specimen; B, cross-section at base of living chamber; both indicating location of siphuncle. See also pl. XLIV, fig. 1.

Fig. 12. *Zitteloceras* (?) *tenuistriatum* (Hall). Cross-section at top of specimen. See also pl. XLIII, fig. 4.

Fig. 13. *Zitteloceras percurvatum* Foerste. A, cross-section at top of specimen; B, ventral side with outline of hyponomic sinus indicated by transverse striae. See also pl. XLIII, fig. 1.

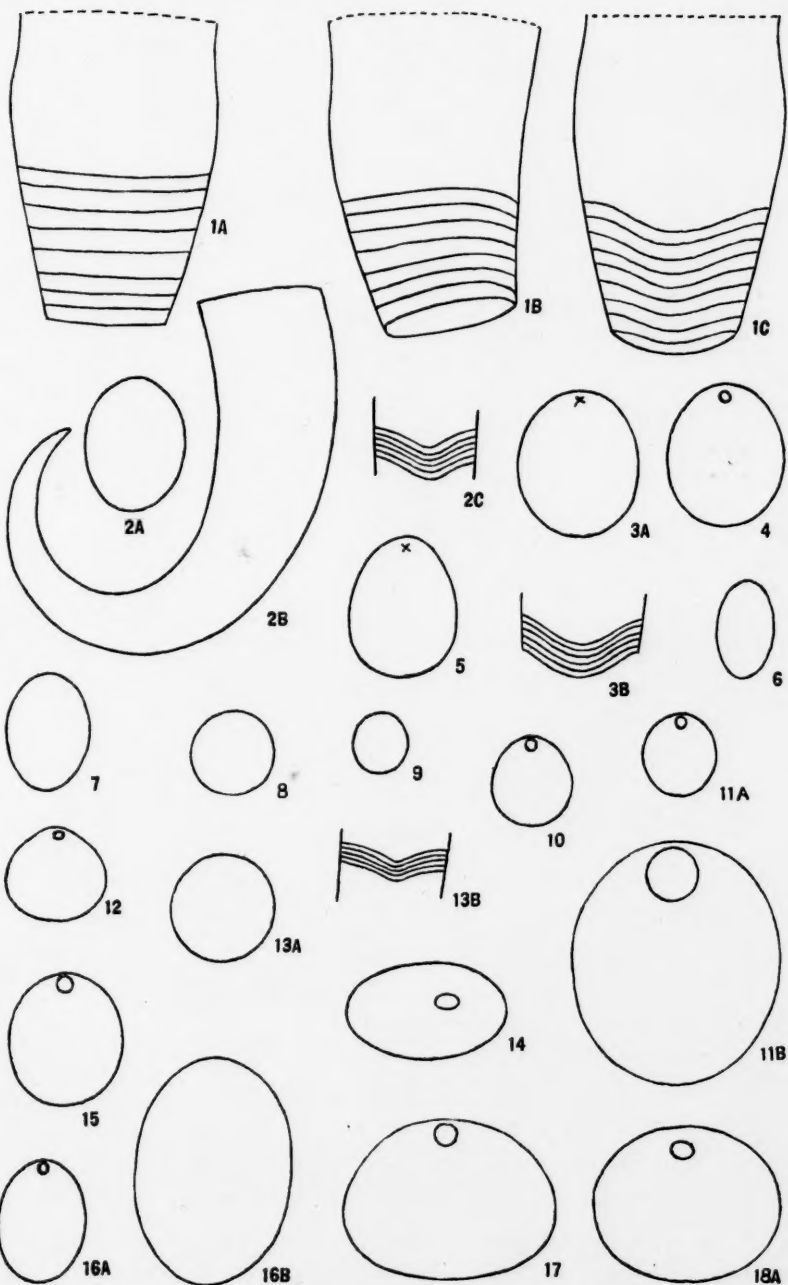
Fig. 14. *Orthoceras clavatum* Hall. Cross-section at break near upper end of specimen showing oblique location of siphuncle in present compressed condition of conch. See also pl. XLV, fig. 6.

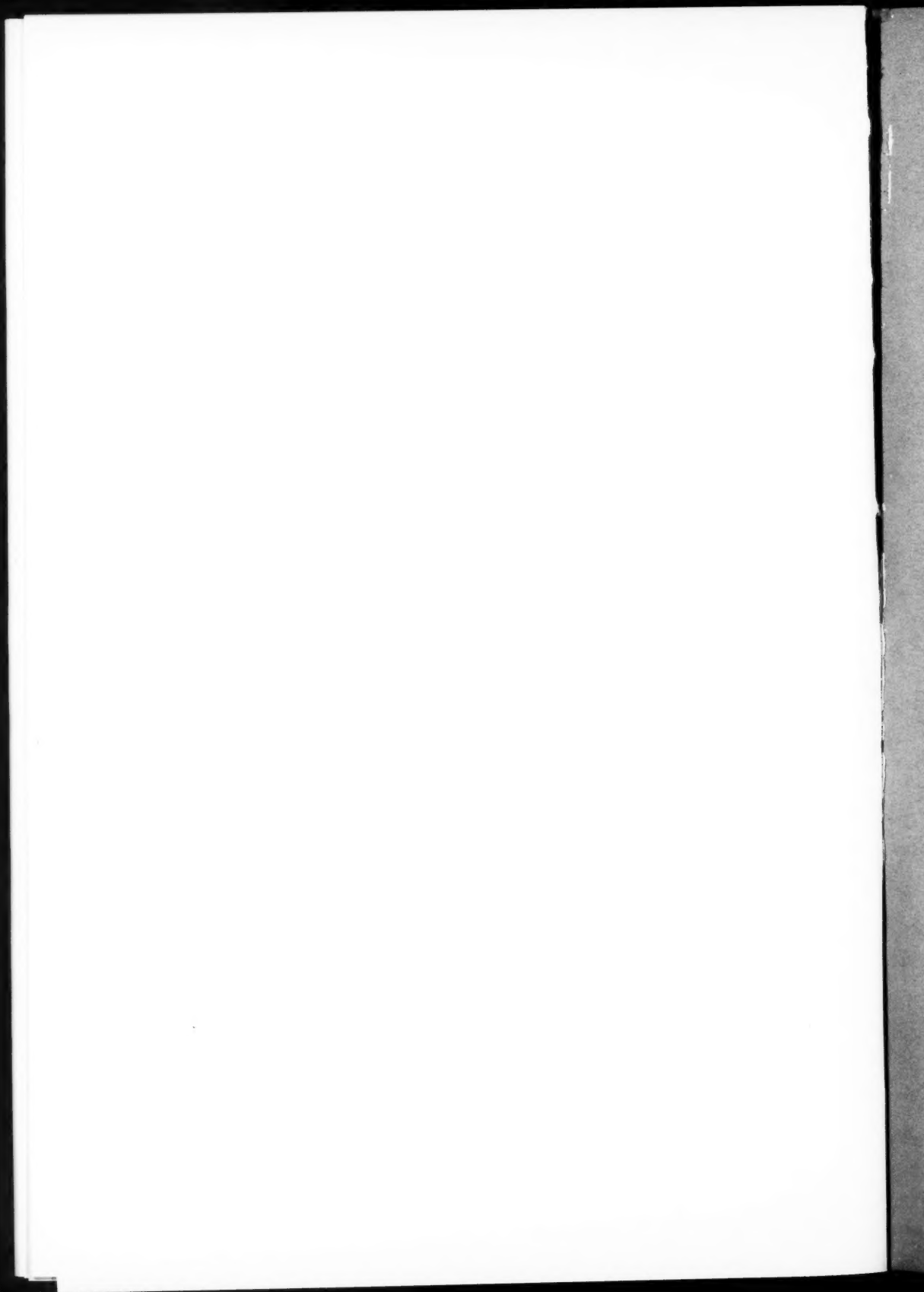
Fig. 15. *Cyrtorizoceras whitneyi* (Hall). Cross-section at base of specimen. See also pl. XLII, fig. 6.

Fig. 16. *Cyrtorizoceras whitneyi* (Hall). A, cross-section at base of specimen; B, cross-section at base of living chamber. See also pl. XLII, fig. 5.

Fig. 17. *Amphicyrtoceras abruptum* Hall. Cross-section at base of specimen. See also pl. XLVI, fig. 6.

Fig. 18. *Amphicyrtoceras* sp. (Niagara Falls). Cross-section at base of specimen. See also pl. XLVI, fig. 3.





VOLUME 17

Articles 1-4, pp. 1-201; March, 1913.....	\$1.50
A geographic interpretation of Cincinnati, Ohio; Edith M. Southall. 16 pp.	
Strophomena and other fossils from Cincinnati and Mohawkian horizons, chiefly in Ohio, Indiana, Kentucky; Aug. F. Foerste. 168 pp., 15 plates.	
Population centers and density of population; F. Carney. 15 pp.	
The climate of Ohio; F. Carney. 9 pp.	
Articles 5-7, pp. 202-246; March, 1913.....	\$0.40
The twenty-fifth anniversary of the founding of the Denison Scientific Association; 2 pp.	
The foundation of culture; C. Judson Herrick. 14 pp.	
Drainage changes in the Moots Run area, Licking County, Ohio; Harmon A. Nixon and Dexter J. Tight. 11 pp., 1 fig.	
Some pre-glacial lake shorelines of the Bellevue Quadrangle, Ohio; F. Carney. 16 pp., 3 figs.	
Articles 8-10, pp. 247-373; March, 1914.....	\$1.00
Lorraine faunas of New York and Quebec; Aug. F. Foerste. 85 pp., 5 plates.	
A comparative study of circular and rectangular Inhoff tanks; Theodore Sedgwick Johnson. 26 pp.	
Geographic factors in the establishing of the Ohio-Michigan boundary line; Constance Grace Eirich. 7 pp.	
Articles 11-14; pp. 374-487; September, 1914.....	\$1.00
A method of subdividing the interior of a simply closed rectifiable curve with an application to Cauchy's theorem; F. B. Willy and G. A. Blinn. 14 pp., 3 figs.	
The influence of glaciation on agriculture in Ohio; Edgar W. Owen. 4 pp., 1 fig.	
The Locust Grove Baker, Ohio; James D. Thompson, Jr. 4 pp., 1 fig.	
Notes on Agalarinidae and Lepadoecyinae, with descriptions of Threherodiscus and Brockocystis; Aug. F. Foerste. 38 pp., 5 plates.	

VOLUME 18

Articles 1-3, pp. 1-284; December, 1915.....	\$1.75
Proceedings of the inauguration of President Chamberlain; 54 pp.	
Denison University presidents; William Hannibal Johnson. 5 pp.	
The fauna of the Morrow Group of Arkansas and Oklahoma; Kirtley F. Mather. 236 pp., 2 figs., 16 plates.	
Articles 4-7, pp. 285-375; December, 1916.....	\$1.10
Notes on Cincinnati fossil types; Aug. F. Foerste. 71 pp., 7 plates.	
The shorelines of glacial lakes Lundy, Wayne, and Arkona, of the Oberlin Quadrangle, Ohio; Frank Carney. 5 pp., 1 fig.	
The progress of Geology during the period 1891-1915; Frank Carney. 3 pp., 4 figs.	
The abandoned shorelines of the Ashtabula Quadrangle, Ohio; Frank Carney. 34 pp., 4 figs.	

VOLUME 19

Articles 1-4, pp. 1-94; April, 1919.....	\$0.75
Echinodermata of the Bransfield (Silurian) formation of Ohio; Aug. F. Foerste. 30 pp., 7 plates.	
America's advances in potash production; W. C. Ebaugh. 14 pp., 2 figs.	
The use of outline charts in teaching vertebrate paleontology; Maurice G. Mehl. 8 pp., 1 fig., 4 plates.	
Some factors in the geographic distribution of petroleum; Maurice G. Mehl. 9 pp., 2 plates.	
Articles 5-8, pp. 95-146; September, 1919.....	\$0.75
Notes on Isotelus, Achrolochea, Calymene and Encrinurus; Aug. F. Foerste. 12 pp., 6 plates.	
Some suggested experiments for the graphic recording of speech vibrations; Robert James Kellogg. 14 pp., 4 figs.	
The manipulation of the telescopic alidade in geologic mapping; Kirtley F. Mather. 46 pp., 13 figs.	
The importance of drainage area in estimating the possibilities of petroleum production from an anticlinal structure; Kirtley F. Mather and Maurice G. Mehl. 4 pp., 2 plates.	
Articles 9-12, pp. 147-231; May, 1920.....	\$0.75
Physiological factors in vocational guidance; Thomas A. Lewis. 10 pp.	
The use of models in the interpretation of data for determining the structure of bedded rocks; Maurice G. Mehl. 12 pp., 6 figs., 2 plates.	
Some suggestions for indicating drilling operations; Maurice G. Mehl. 6 pp., 3 figs.	
The Kimmswick and Plattin limestones of Northwestern Missouri; Aug. F. Foerste. 50 pp., 3 plates.	
Articles 13-16, pp. 232-329; September, 1921.....	\$0.75
Education for scholarship; William E. Castle. 9 pp.	
The cytology of the sea-urchin earwig, <i>Animula maritima</i> Bon., part 1; Sidney I. Kornhauser. 12 pp., 9 plates.	
Notes on Arctic Ordovician and Silurian cephalopods; Aug. F. Foerste. 60 pp., 9 plates.	
Revolution vs. evolution: the paleontologist reads his verdict; Kirtley F. Mather. 16 pp.	

VOLUME 20

Articles 1-3, pp. 1-36; November, 1923.....	\$0.50
A review of the biology of sex-determination; Sidney L. Kornhauser. 31 pp., 3 figs.	
The Meander patterns of Rice Secour and Mamore, Eastern Bolivia; Kirtley F. Mather. 7 pp., 3 figs.	
Primitive musical instruments of the Denison Collection; Karl H. Eschman. 10 pp., 3 plates.	
Articles 4-8, pp. 37-190; June, 1923.....	\$0.75
Notes on Medinan, Niagaran, and Chester fossils; Aug. F. Foerste. 64 pages, 13 plates.	
The egg and larvae of <i>Hesperia juba</i> Bdv.; A. W. Lindsey. 7 pp., 1 plate.	
The occultation of Venus by the Moon on January 13, 1923; P. Bisfeld. 4 pp., 1 plate.	
A botanical survey of the campus of Denison University; Dwight Munson Moore. 23 pp., 7 figs. 3 plates.	
The underground migration of oil and gas; Kirtley F. Mather. 31 pp., 1 fig.	
Articles 9-12, pp. 187-265; December, 1924.....	\$1.25
<i>Trichoptilus pygmaeus</i> Wism. and the Neuration of the Family Pterophoridae; A. W. Lindsey. 6 pp., 6 plates.	
Notes on American Paleozoic Cephalopods; Aug. F. Foerste. 76 pp., 23 plates.	
A Report on the Theory of Relativity (Einstein Theory); Paul Bisfeld. 20 pp.	
Some Problems of Taxonomy; A. W. Lindsey. 16 pp., 1 plate.	
Notes on the Geology of Giles County, Virginia; George D. Hubbard and Carey G. Cronsis. 73 pp., 1 plate.	

VOLUME 21

Articles 1-3, pp. 1-116; March, 1925.....	\$1.50
Notes on Cephalopod Genera; Chiefly Coiled Silurian Forms; Aug. F. Foerste. 70 pp., 23 plates.	
The Cornell University Entomological Expedition to South America of 1919-1920. Scientific Results No. II. Hesperioidea; A. W. Lindsey. 44 pp., 6 plates.	
Photographic Record of the Partial Solar Eclipses of January 24, 1925; Paul Bisfeld. 2 pp., 1 plate.	
Article 4, pp. 117-228; September, 1925.....	\$1.50
The Agricultural Geography of the Salt Lake Oasis; Charles Langdon White. 107 pp., 34 figs.	
Articles 5-7, pp. 229-404; September, 1925.....	\$1.25
Actinophionate, Trochoceroide and other Cephalopods; Aug. F. Foerste. 100 pp., 23 plates.	
Brachiopods from the St. Clair Limestone, Arkansas; Norman L. Thomas. 18 pp., 1 plate.	
Notes on the Preparation of Hydrogen Sulfide and Hydrogen Iodide; W. O. Elough. 2 pp.	

VOLUME 22

Articles 1-4, pp. 1-125, March, 1927.....	\$1.50
Ordovician and Silurian Cephalopods of the Hudson Bay Area; Aug. F. Foerste and T. E. Savage. 106 pp., 34 plates, 1 map.	
Notes on Phylogeny in <i>Erynnis</i> Sohr. (Thanaos Auct.); A. W. Lindsey. 7 pp., 1 fig.	
The Blue Ridge of Southern Virginia and Western North Carolina; Frank J. Wright. 17 pp., 4 figs., 2 plates.	
Gravels of the Blue Ridge; Frank J. Wright. 3 pp., 1 fig.	
Articles 5-9, pp. 127-193, October, 1927.....	\$1.00
Science and Religion (Address); Robert A. Millikan. 10 pp.	
Forty Years of Scientific Thought Concerning the Origin of Life (Address); Kirtley F. Mather. 11 pp.	
Darwin as a Pioneer in Evolution (Address); George A. Dorsey. 14 pp.	
Science and Living (Address); C. Judson Herrick. 9 pp.	
Founding of the Denison Scientific Association (Address); Alfred D. Cole. 6 pp.	

VOLUME 23

Articles 1-2, pp. 1-126, January, 1929.....	\$1.50
American Arctic and Related Cephalopods; Aug. F. Foerste. 110 pp., 26 plates.	
<i>Apetodonosaurus</i> , a New Genus of Ichthyosaurs from the Jurassic of Wyoming; M. G. Mehl. 16 pp., 2 figs., 6 plates.	
Articles 3-5, pp. 127-220, July, 1929.....	\$1.50
Some Brachiopods from the St. Clair Limestone, Arkansas; Norman L. Thomas. 15 pp., 1 plate.	
The Phytosauria of the Wyoming Triassic. M. G. Mehl. 23 pp., 9 figs., 3 plates.	
A Restudy of some of the Ordovician and Silurian Cephalopods described by Hall. Aug. F. Foerste. 58 pp., 8 plates.	

NOTE: In accordance with a ruling of the postal authorities it has become necessary to change the name of this publication from "BULLETIN" to "JOURNAL" of the SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY.

